CLIMsystems

Compendium of Products and Services

CLIMsystems

Company Overview

CLIMsystems has assembled an excellent team of climate change adaptation and risk assessment experts with a combined experience of over 200 years with projects in over 50 countries. CLIMsystems is also an accredited member of the CTCN (Climate Technology Centre & Network). CTCN is the operational arm of the UNFCCC Technology Mechanism, hosted by the UN Environment Programme (UNEP) and the UN Industrial Development Organization (UNIDO). The Centre promotes the accelerated transfer of environmentally sound technologies for low carbon and climate resilient development at the request of developing countries. CTCN members provide technology solutions, capacity building and advice on policy, legal and regulatory frameworks tailored to the needs of individual countries. CLIMsystems maintains an impressive list of international associates and a scientific advisory panel Chaired by Emeritus Professor Tom Wigley of NCAR (National Center for Atmospheric Research).

CLIMsystems Data Services

- Defensible: scientific robustness and up to date, cross validation.
- Actionable: provide climate and derived analysis results fit for purpose for adaptation planning and engineering projects.
- Legitimate: follow the conventions, guidance and standards of international and country specific, scientific and engineer communities.
- Wide range: provide high resolution and wide range of climate related data obtained through partners and the data mining of respected sources.
- High quality economic analysis of the incremental cost of climate change.

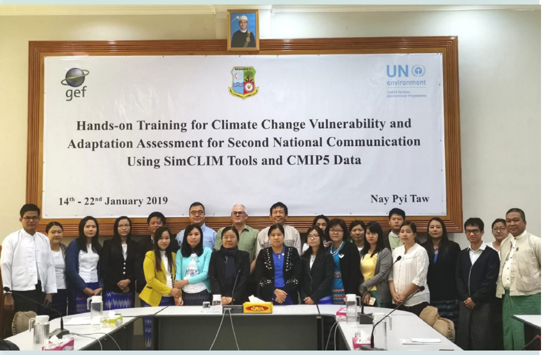
Software and Training

- Designs, develops and markets advanced, user friendly software systems for assessing impacts and adaptation to climate variability and change.
- Offers software licenses and associated training services, technical assistance and coaching to a range of national and local governments, planners, educators, students, international agencies, private consultants and companies throughout the world to meet their needs for addressing climate risk and improving resilience.
- Country specific full semester graduate and master's degree climate change course fit to country tertiary curriculums systems; customized training package with software and data; one to one coaching for PhDs and professionals.

Integrated Adaptation Solutions

- Whether the problem is large or small, straightforward or complex, we have the full-service solution and experience to deliver the answers you need to move forward.
- Early engagement for problem identification, codesign, co-production and co-deliver of solutions. Practical coaching and communication with specific software and data by international experts. Coordinated and comprehensive concerns with different sectors and among project.
- Alignment with international and national conventions and standards.
- High quality data, analysis and visualization.
- High quality risk assessments and decision support facilities for national, sub-national and local project prioritization.

CLIMsystems



Regional Networks

CLIMsystems has extensive networks across Africa and the Middle East, Asia and the Pacific. CLIMsystems participates in CORDEX regional meetings for Asia and the Pacific. This includes specifically the five CORDEX Groups for Africa, MENA, East Asia, South Asia and South East Asia. Our engagement with the CORDEX process and membership leads us to have strong ties with academic institutions throughout the world.

Scientific Advisory Panel

- Prof T.M.L. Wigley (Chair) (University of Adelaide, Australia)
- Dr J. Meehl (National Center for Atmospheric Research, USA)
- Prof B. Hewitson (University of Cape Town, South Africa)
- Prof M. Manton (Monash University, Australia)
- Prof M. Manning (Victoria University of Wellington, New Zealand)
- Dr J. Hunter (Antarctic Climate & Ecosystems Cooperative Centre (ACE CRC))
- Prof R. Wilby (Loughborough University, UK)

Contents

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NEW PRODUCTS and SERVICES

Supply Chain Climate Risk Assessment

Host Informed365
https://www.informed365.com/

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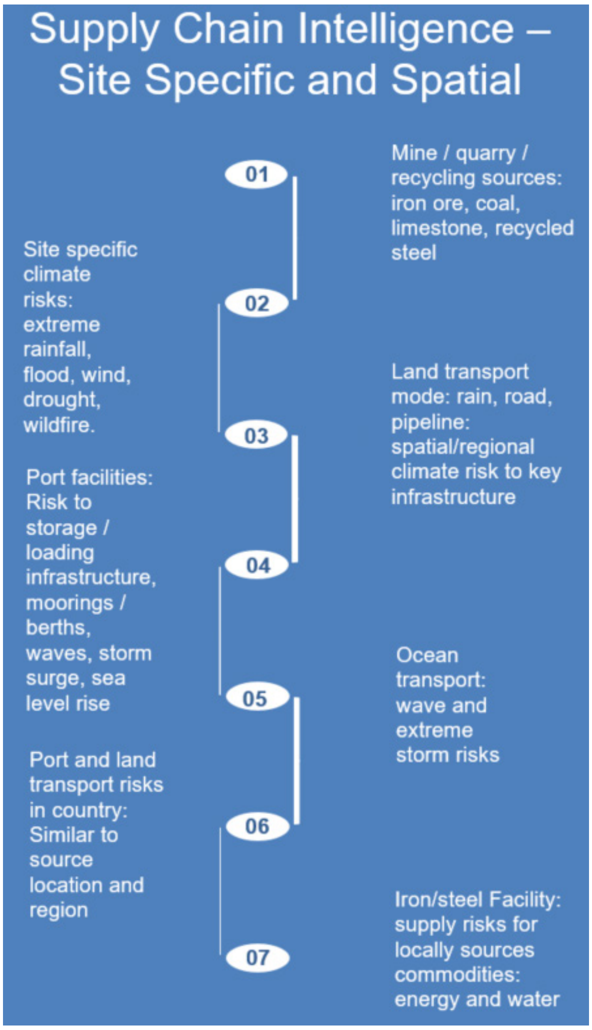
Description



There are at least three areas that procurement and supply chain organisations should examine when assessing the risks that climate change poses to their supply chains.

1] The infrastructure that corporate supply chains rely on to acquire and move goods will begin to experience significant strain (building, ports, roads, rail, airports, river barges . . .

2] Severely reduce crop yields and create water shortages, placing significant constraints on resource availability, particularly in the food industry. Agricultural supply chains have already begun facing the consequences of such conditions.

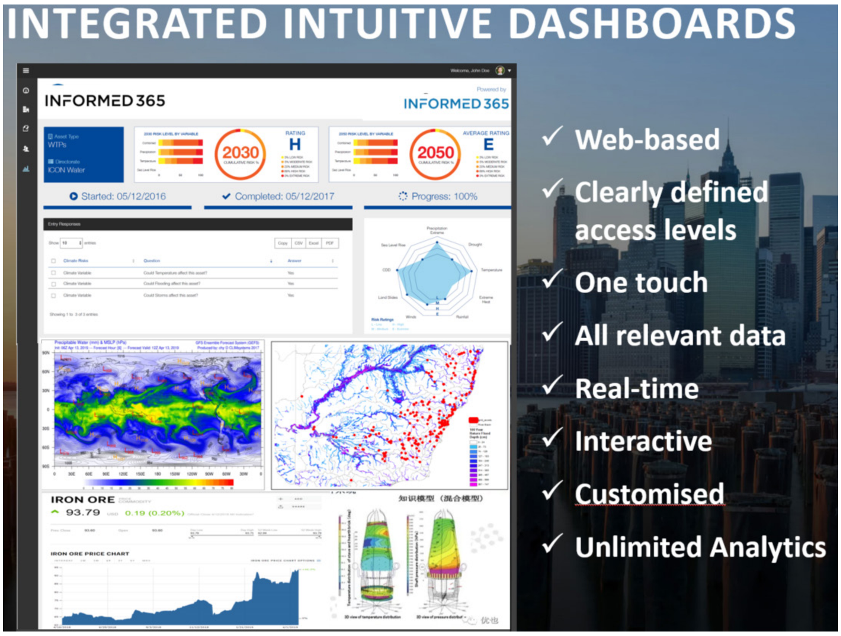
3] The same forces that are expected to strain food supply chains are expected to create social strife and political conflict. Climate variability has been shown to affect conflict through intermediate processes, including resource competition, commodity price shocks, and food insecurity.

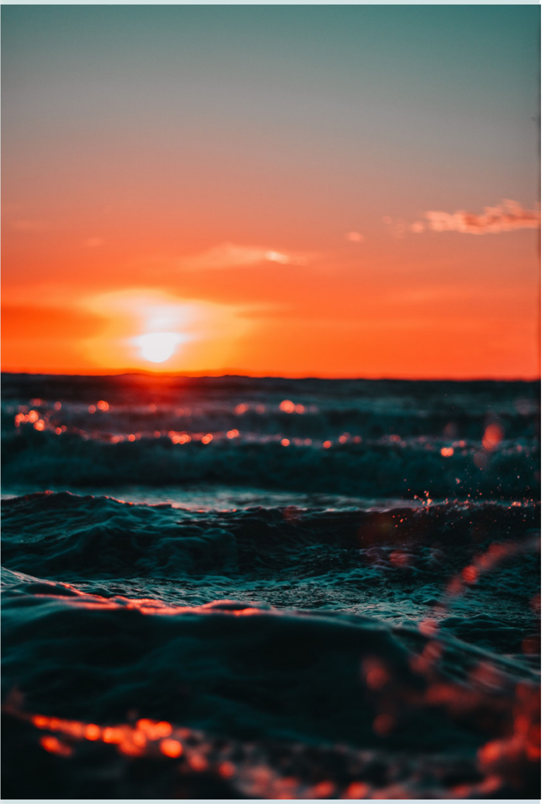
Reducing supply chain risks presented by climate changes is not a long-term thought experiment but an imperative that must be addressed today. While much of the popular discussion around climate change focuses on reducing risks through emissions mitigation (that is also important), from a supply chain planning perspective, reducing risk through adaptation actions is also an essential corporate consideration.

Supply Chain Climate Risk Assessment

CLIMsystems and Informed365 and a host of highly regarded international data providers have teamed up to build on the latest cloud technology a robust platform for providing a highly customizable and thus extremely relevant information to corporate and government entities charged with understanding their supply chain and asset risk and require an efficient way of conducting risk assessments and reporting either internally (to a Board) or publicly in the case of TCFD and to meet other regulatory requirements.

- Any asset e.g.
- Identify risks, likelihood and consequences
- View, track and compare assets and query detailed supply chains
- 32+ climate variables
- Global high-resolution coverage
- Can Include: Climate Governance, Supply Chain Management, Modern Slavery, Carbon Monitoring, Climate Risk Management and Disaster Risk Reduction





Ocean Temperature Modelling

Host CLIMsystems Ltd
http://climsystems.com/

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Description

The memory of past warming events is in the oceans, and even though there are weather events that alter the daily details, the atmosphere above the oceans is warmer and moister than it used to be. At any time, the direct effect of this blanket is small, but the accumulated effects are substantial and have consequences for our weather and climate. Over 90% of the extra heat ends up in the ocean and hence perhaps the most important measurements of global warming are made in the oceans.

Better baseline temperature observations and modelling simulation for future projections, provide critical information for scientific research and climate change risk assessments within the ocean environment and for offshore infrastructure development, safety parameters and operations.

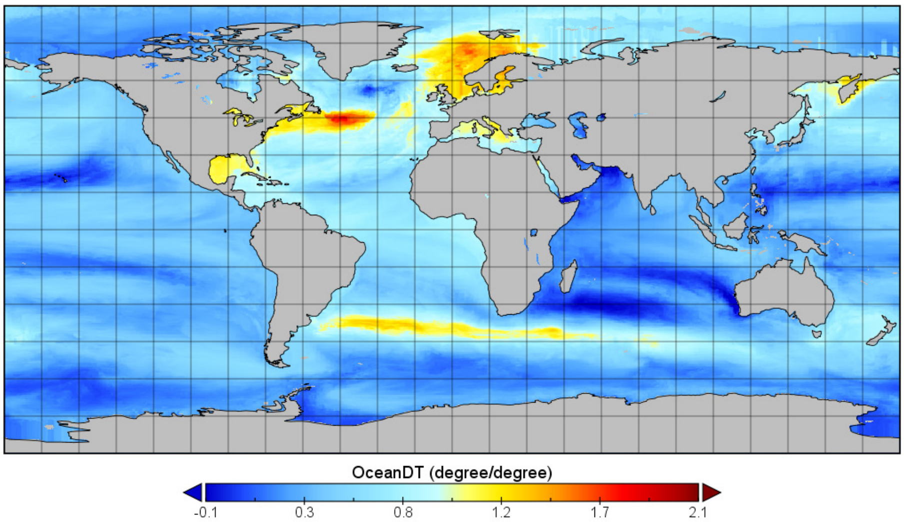
The spatial resolution of the baseline and GCM change patterns is 0.25-degree latitude/longitude.

Baseline dataset: WOA13

The World Ocean Atlas 2013 version 2 (WOA13 V2) is applied and is a set of objectively analysed (1° grid) climatological fields of in situ temperature at standard depth levels for annual, seasonal, and monthly compositing periods for the world's oceans. It also includes associated statistical fields of observed oceanographic profile data interpolated to standard depth levels on 5°, 1°, and 0.25° grids. The data is the monthly climatology of 1955 – 2012 (https://www.nodc.noaa.gov/OC5/woa13/).

Future projections

CMIP5 GCM data: Monthly sea water temperature data is converted from sea water potential temperature(thetao) data.



Sample map for ocean water temperature change 350-meters deep

Ocean Temperature Modelling

Level (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	20.0	19.3	19.0	20.1	21.4	24.9	27.2	27.8	28.4	27.3	24.7	22.2
5	19.9	19.2	19.0	20.0	21.2	24.8	27.2	27.8	28.3	27.2	24.6	22.2
10	19.8	19.0	18.8	19.9	21.1	24.7	27.1	27.6	28.2	27.0	24.5	22.1
15	19.6	18.8	18.6	19.7	20.8	24.3	27.0	27.5	27.8	26.4	24.3	21.9
20	19.4	18.5	18.3	19.3	20.3	23.5	26.8	27.2	27.3	25.6	23.8	21.7
25	19.2	18.3	18.0	18.9	19.9	22.4	26.4	26.7	26.4	24.4	23.0	21.2
30	19.0	17.9	17.6	18.4	19.5	21.6	25.5	25.5	25.2	22.9	22.2	20.6
35	18.7	17.6	17.1	18.0	18.9	20.9	24.5	24.3	24.1	21.5	21.5	19.9
40	18.4	17.2	16.6	17.5	18.5	20.4	23.3	23.2	22.4	20.0	20.7	19.2
45	17.9	16.8	16.2	17.0	18.0	19.8	22.2	22.0	21.1	19.0	19.7	18.6
50	17.4	16.4	15.8	16.6	17.4	19.3	20.8	21.0	20.1	18.1	18.9	18.0
55	17.0	16.1	15.6	16.3	17.2	18.7	19.8	19.1	19.3	17.3	17.9	17.6
60	16.6	15.8	15.4	15.9	16.9	18.4	19.1	18.3	18.4	16.7	17.3	17.1
65	16.3	15.5	15.2	15.7	16.6	18.1	18.3	17.8	17.9	16.3	16.8	16.7
70	16.1	15.3	15.1	15.4	16.3	17.8	17.7	17.3	17.2	16.0	16.5	16.3
75	15.9	15.2	14.9	15.2	16.1	17.6	17.3	16.9	16.7	15.7	16.2	16.0
80	15.6	15.0	14.8	15.1	16.0	17.1	16.7	16.4	16.4	15.5	16.0	15.8
85	15.4	14.9	14.7	14.9	15.8	17.0	16.3	16.1	15.9	15.3	15.8	15.6
90	15.3	14.8	14.6	14.8	15.6	16.7	16.0	15.7	15.6	15.1	15.5	15.5
95	15.1	14.6	14.4	14.7	15.5	16.4	15.8	15.5	15.4	15.0	15.3	15.4
100	14.9	14.5	14.3	14.6	15.3	16.3	15.5	15.3	15.1	14.9	15.1	15.2
125	14.4	13.9	13.9	14.2	14.6	15.4	14.8	14.4	14.3	14.3	14.4	14.6
150	13.9	13.6	13.6	14.0	14.0	14.7	14.2	13.8	13.8	13.7	14.0	14.3
175	13.4	13.2	13.4	13.5	13.5	14.2	13.7	13.4	13.4	13.3	13.6	13.8
200	13.2	13.0	13.0	13.2	13.1	13.6	13.3	13.0	13.0	13.1	13.3	13.4
225	12.8	12.8	12.6	12.7	12.8	13.0	12.8	12.7	12.6	12.8	13.0	13.0
250	12.5	12.5	12.6	12.5	12.6	12.8	12.5	12.4	12.4	12.6	12.8	12.9
275	12.2	12.3	12.3	12.3	12.3	12.7	12.2	12.1	12.1	12.4	12.5	12.6
300	11.9	12.2	12.1	12.1	12.0	12.3	12.1	11.8	12.0	12.1	12.3	12.4
325	11.7	11.9	11.8	11.9	11.8	12.0	11.8	11.6	11.6	11.9	12.0	12.1
350	11.3	11.6	11.6	11.6	11.5	11.7	11.6	11.4	11.4	11.7	11.8	11.9
375	11.0	11.3	11.4	11.3	11.2	11.5	11.3	11.1	11.2	11.4	11.6	11.6
400	10.7	11.0	11.1	11.0	10.9	11.2	11.1	10.9	11.0	11.1	11.3	11.3
425	10.5	10.7	10.8	10.8	10.6	11.0	10.8	10.5	10.7	10.8	11.1	11.1
450	10.2	10.5	10.5	10.5	10.2	10.7	10.5	10.2	10.4	10.5	10.8	10.7
475	10.0	10.1	10.2	10.2	9.9	10.3	10.0	9.9	10.1	10.3	10.5	10.4
500	9.7	9.7	9.9	9.9	9.5	9.9	9.7	9.6	9.9	10.0	10.2	10.2
550	9.3	9.4	9.4	9.4	8.9	9.2	9.2	9.2	9.4	9.4	9.7	9.4
600	8.7	8.8	8.9	8.7	8.4	8.8	8.7	8.6	8.8	8.9	9.2	8.9
650	8.3	8.0	8.1	8.2	8.2	8.2	8.2	8.0	8.4	8.3	8.5	8.4
700	7.7	7.8	7.7	7.7	7.6	7.6	7.5	7.6	7.7	7.8	7.9	8.1
750	7.4	7.3	7.2	7.3	7.2	7.3	7.2	7.1	7.2	7.5	7.6	7.7
800	7.0	7.0	6.9	7.0	6.7	6.9	6.8	6.7	6.8	7.1	7.2	7.3
850	6.6	6.7	6.7	6.8	6.6	6.6	6.6	6.7	6.8	6.6	6.8	6.8
900	6.3	6.3	6.3	6.4	6.3	6.4	6.4	6.2	6.3	6.5	6.6	6.5
950	6.0	6.2	6.0	6.2	6.1	6.1	6.2	6.0	6.2	6.2	6.2	6.2
1000	5.9	5.9	5.8	6.0	5.9	5.9	6.0	5.9	5.9	6.0	6.1	6.0
1050	5.7	5.7	5.8	5.8	5.7	5.8	5.8	5.7	6.0	5.8	5.9	5.8
1100	5.5	5.6	5.6	5.8	5.6	5.6	5.7	5.5	5.8	5.7	5.7	5.8
1150	5.3	5.4	5.4	5.6	5.5	5.4	5.5	5.4	5.6	5.5	5.5	5.5

Ocean Temperature Modelling

NO	Model	Country	Grid numbers for atmo-spheric variables (lon*lat)	Grid numbers for ocean variables (lon*lat)	Ocean tem-perature levels
1	ACCESS1.0	Australia	192*145	360*300	50
2	ACCESS1.3	Australia	192*145	360*300	50
3	CanESM2	Canada	128*64	256*192	40
4	CMCC-CESM	Italy	192*96	182*149	31
5	CMCC-CM	Italy	192*96	182*149	31
6	CMCC-CMS	Italy	192*96	182*149	31
7	CNRM-CM5	France	256*128	362*292	42
8	CSIRO-Mk3-6-0	Australia	192*96	192*189	31
9	GFDL-CM3	USA	144*90	360*200	50
10	GFDL-ESM2G	USA	144*90	360*210	50
11	GFDL-ESM2M	USA	144*90	360*200	50
12	GISS-E2-H	USA	144*90	144*90	33
13	GISS-E2-H-CC	USA	144*90	144*90	33
14	GISS-E2-R	USA	144*90	288*180	32
15	GISS-E2-R-CC	USA	144*90	288*180	32
16	HadGEM2-CC	UK	192*145	360*216	40
17	HadGEM2-ES	UK	192*145	360*216	40
18	INMCM4	Russia	180*120	360*340	40
19	IPSL-CM5A-LR	France	96*96	182*149	31
20	IPSL-CM5A-MR	France	144*142	182*149	31
21	IPSL-CM5B-LR	France	96*96	182*149	31
22	MIROC5	Japan	256*128	256*224	33
23	MIROC-ESM	Japan	128*64	256*192	44
24	MIROC-ESM-CHEM	Japan	128*64	256*192	44
25	MPI-ESM-LR	Germany	192*96	256*220	40
26	MPI-ESM-MR	Norway	192*96	802*404	40
27	MRI-CGCM3	Japan	320*160	360*368	51
28	NorESM1-M	Norway	144*96	320*384	70
29	NorESM1-ME	Norway	144*96	320*384	70

Precipitation-based Agricultural Drought Indices

Host CLIMsystems Ltd
http://climsystems.com/

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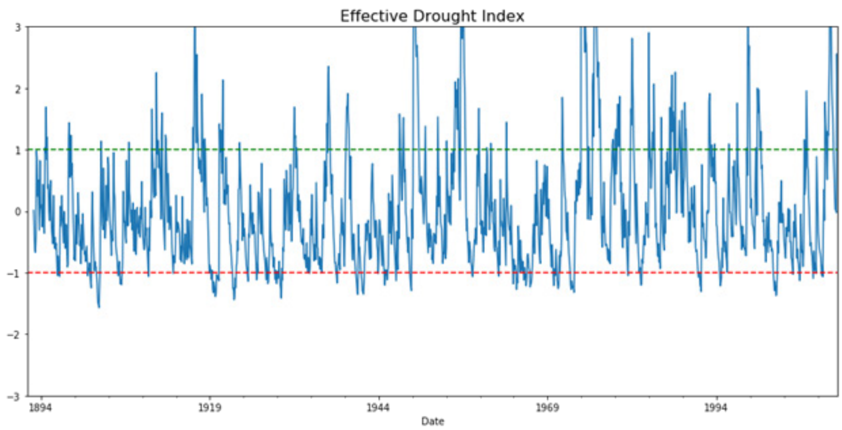
Description

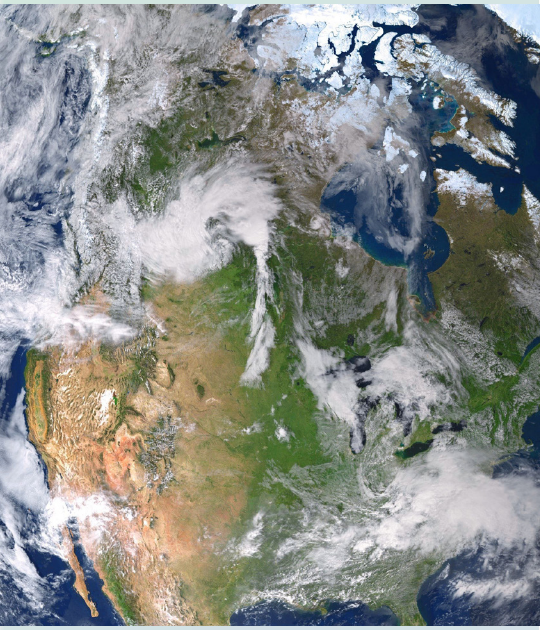
Drought is an insidious natural hazard that results from a deficiency of precipitation from expected or “normal” that, when extended over a season or longer period, is insufficient to meet the demands of human activities and the environment. Drought has had a significant impact on agriculture. The increasing frequency and magnitude of droughts in recent decades and the mounting losses from extended droughts in the agricultural sector emphasize the need for assigning an urgent priority to addressing the issue of agricultural droughts.

Precipitation-based indices are generally considered as the simplest indices because they are calculated solely based on long-term rainfall records that are often available. Even though the paucity of rain is a main cause of agricultural drought, rainfall data alone may often be insufficient to assess the effect of drought on agricultural productivity. Nevertheless, use of rainfall has considerable value in providing effective summaries of droughts, and, provided the purpose is clearly and precisely defined in terms of activity, location, and timing, rainfall data can greatly assist activities such as drought policy decisions.

CLIMsystems provide a set of precipitation-based indices:

- Decile Index (DI)
- Hutchinson Drought Severity Index (HDSI)
- Percent of Normal Index (PNI)
- Z-Score Index (ZSI)
- China-Z Index (CZI)
- Modified China-Z Index (MCZI)
- Rainfall Anomaly Index (RAI)
- Effective Drought Index (EDI)
- Standardized Precipitation Index (SPI).





Real-time Review of Global Precipitation and Temperature

Host CLIMsystems Ltd
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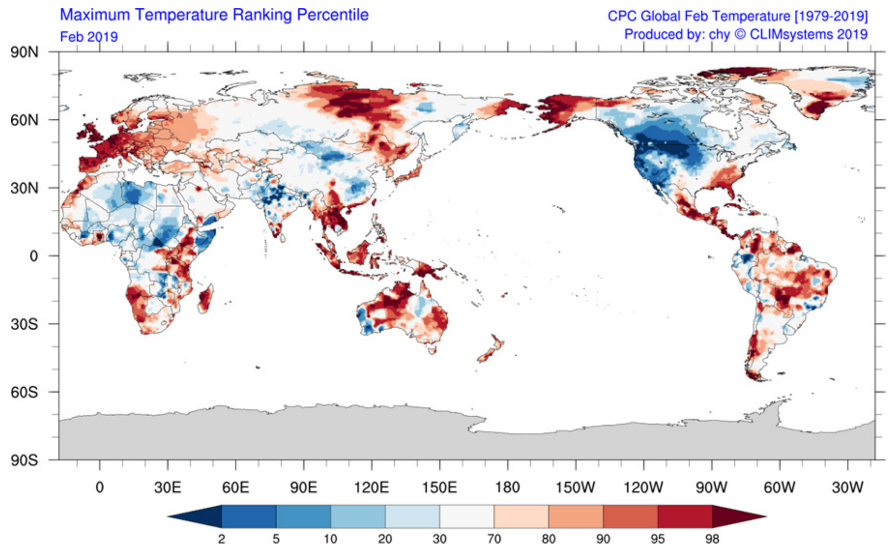
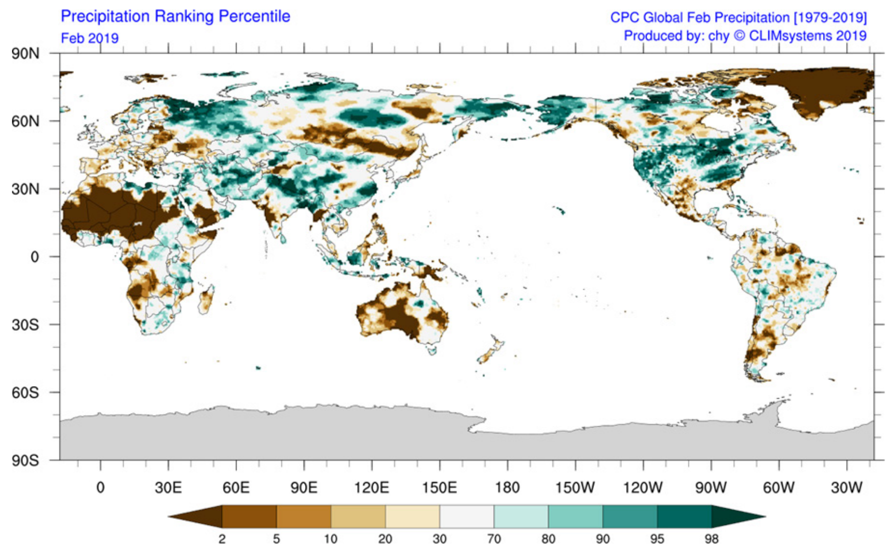
Description

Based on CPC global daily data, CLIMsystems provide real-time review of global temperature and precipitation at multiple temporal scales (e.g., weekly, dekadly and monthly). Generally, this product is applied in combination with our seasonal drought forecast products.

At present, the ranking percentiles of maximum temperature and precipitation are updated regularly. These indices could provide the location information of current climate in the context of historical time series. Other indices could be accessed as request such as Anomaly, SPI and SPEI.





Seasonal Forecast-based Drought Early Warning System

Host CLIMsystems Ltd
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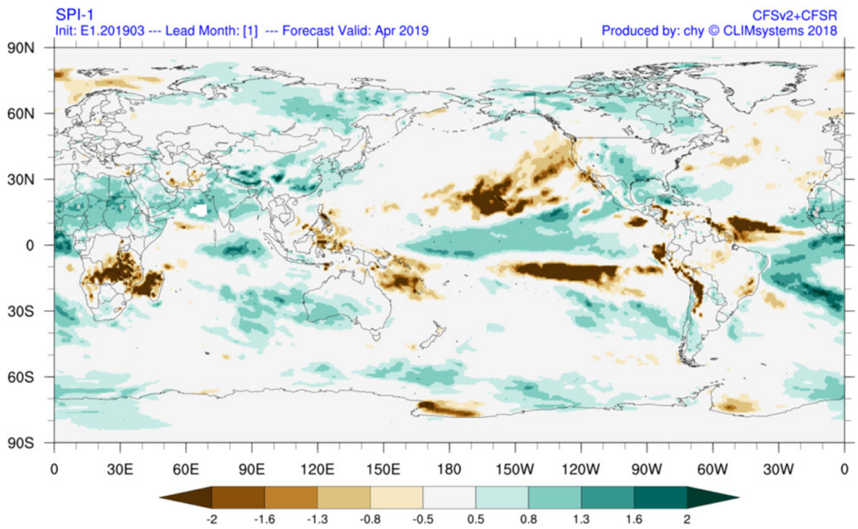
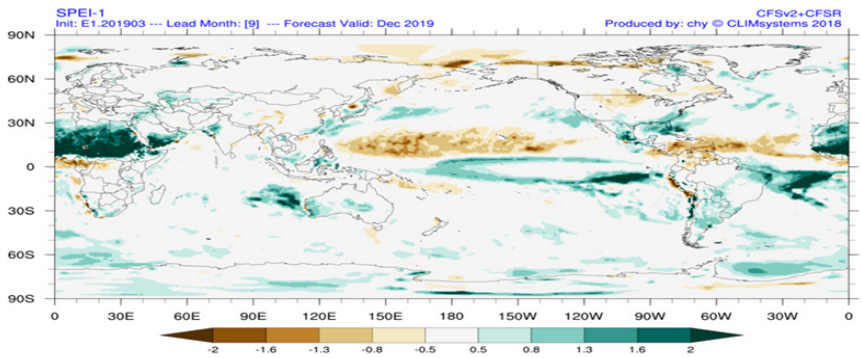
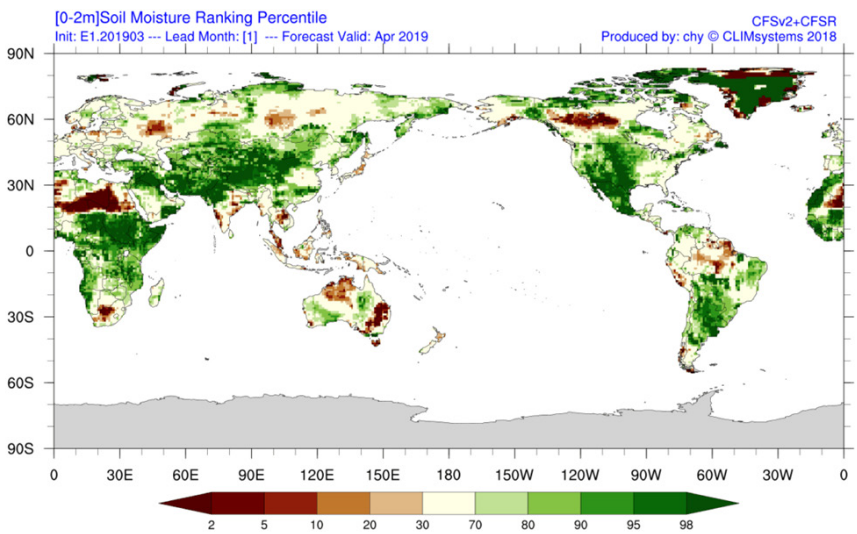
Description

Based on our CFSv2 seaonal forecast products, CLIMsystems provide additional drought early warning service using the indices of SPI, SPEI and ranking percentile of soil moisture. The service could provide a 9-month-lead forecast.







Drought Indices Based on Multiple Variables

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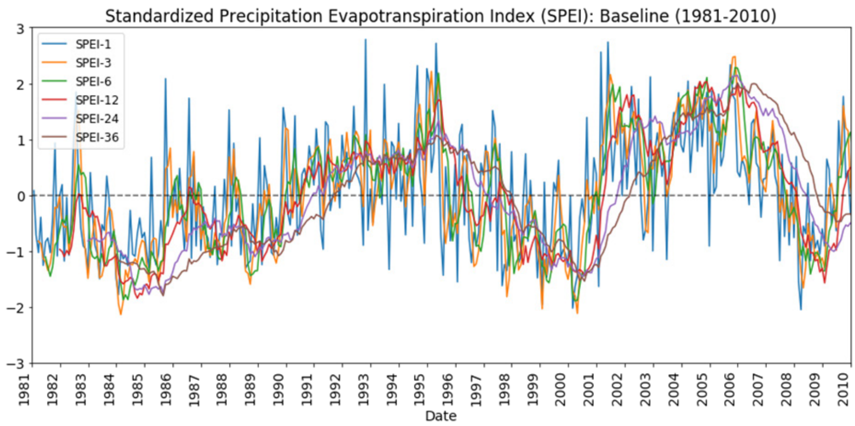
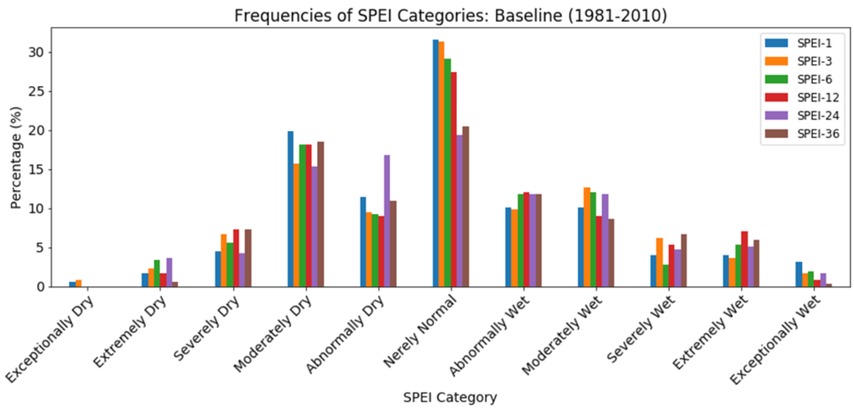
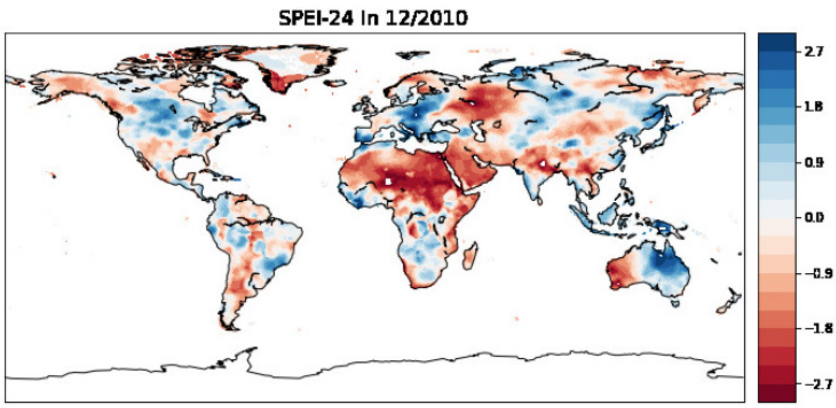
Description

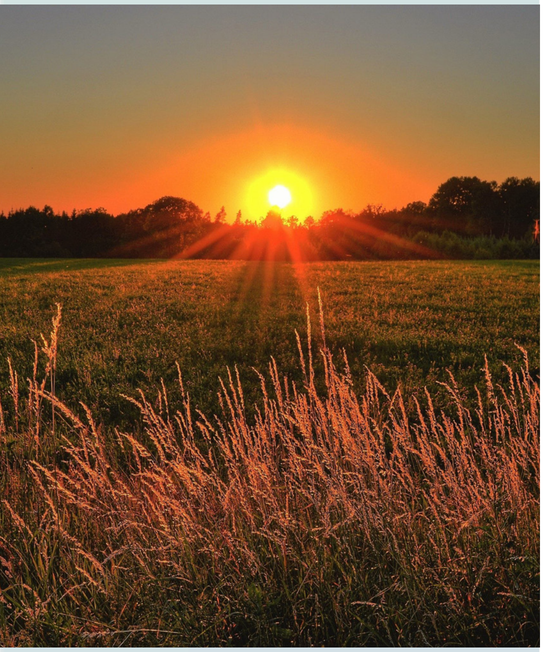
Besides the precipitation-based indices for agricultural drought, CLIMsystems also provide more complicated drought indices calculated from multiple meteorological variables for the site specific and spatial scales:

- SPEI: Standardized Precipitation Evapotranspiration Index
- PDSI: Palmer Drought Severity Index
- scPDSI: Self-calibrated Palmer Drought Severity Index
- PHDI: Palmer Hydrological Drought Index
- Z-Index: Palmer moisture anomaly index (Z-index)
- PMDI: Palmer Modified Drought Index









BioCLIM Variables

Host CLIMsystems Ltd
http://climsystems.com/

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Description

Bioclimatic variables are derived from the monthly temperature and rainfall values in order to generate more biologically meaningful variables. These variables capture information about annual conditions (annual mean temperature, annual precipitation, annual range in temperature and precipitation), as well as seasonal mean climate conditions and intra-year seasonality (temperature of the coldest and warmest months, precipitation of the wettest and driest quarters).

They are often used in species distribution modelling and related ecological modelling techniques. Moreover, examining climate over time is useful when quantifying the effects of climate changes on species distributions for past, current, and forecasted scenarios. These indices can provide biologists and ecologists with relevant and multi-scaled climate data to augment research on the responses of species to changing climate conditions (O'Donnell and Ignizio, 2012).

- **BIO 01** Annual mean temperature as the mean of the monthly temperatures (°C)
- **BIO 02** Mean diurnal range as the mean of monthly (max temp - min temp) (°C)
- **BIO 03** Isothermality (BIO2/BIO7 * 100)
- **BIO 04** Temperature Seasonality (standard deviation * 100)
- **BIO 05** Max Temperature of Warmest Month (°C)
- **BIO 06** Min Temperature of Coldest Month (°C)
- **BIO 07** Temperature Annual Range (BIO5 - BIO6) (°C)
- **BIO 08** Mean Temperature of Wettest Quarter (°C)
- **BIO 09** Mean Temperature of Driest Quarter (°C)
- **BIO 10** Mean Temperature of Warmest Quarter (°C)
- **BIO 11** Mean Temperature of Coldest Quarter (°C)
- **BIO 12** Annual Precipitation (mm)
- **BIO 13** Precipitation of Wettest Month (mm)
- **BIO 14** Precipitation of Driest Month (mm)
- **BIO 15** Precipitation Seasonality (Coefficient of Variation * 100)
- **BIO 16** Precipitation of Wettest Quarter (mm)
- **BIO 17** Precipitation of Driest Quarter (mm)
- **BIO 18** Precipitation of Warmest Quarter (mm)
- **BIO 19** Precipitation of Coldest Quarter (mm).

Wildfire Indices

Host CLIMsystems Ltd
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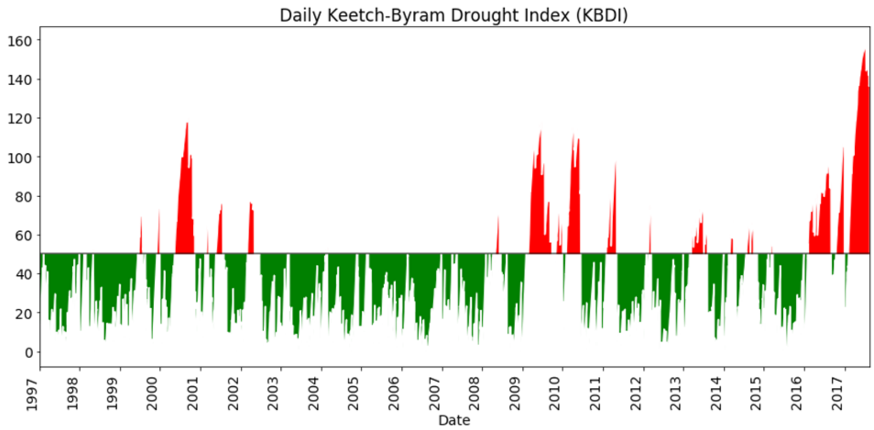
Description

Globally, the occurrence of vegetation fires is common in all continents. Natural vegetation fires have been documented since prehistoric times and have significantly shaped the composition and dynamics of some ecosystems, including forests and open landscapes. In addition to global impacts, fires also have serious local impacts, which are commonly associated with fire frequency and intensity, and imply loss of life and infrastructure, soil degradation, and changes in vegetation and biodiversity.

CLIMsystems provide the following indices to assess the risk of wildfire:

- Keetch-Byram Drought Index (KBDI) and Forest Fire Danger Index (FFDI): Calculated from daily surface-level meteorological data. KBDI and FFDI are commonly used metrics for assessing drought and fire danger in South Africa and Australia.
- Canadian Fire Weather Index (FWI): The FWI System (Van Wagner and Pickett 1985; Van Wagner 1987) is a weather-based means of calculating potential fire conditions in Canada's forests.



Land Heat Wave and Marine Heat Wave

Host

CLIMsystems Ltd
http://climsystems.com/

Contact

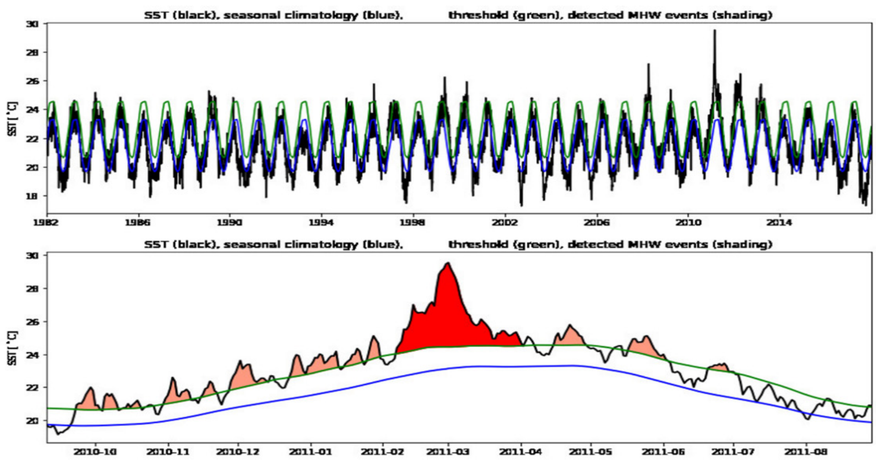
peter@climsystems.com

Description

A **heatwave** refers to a prolonged period of hot weather, which may be accompanied by high humidity. Severe heat waves have caused catastrophic crop failures, thousands of deaths from hyperthermia, and widespread power outages due to increased use of air conditioning. A heat wave is considered extreme weather, and a danger because heat and sunlight may overheat the human body.

Index	Description	Units
HWA	Peak of the hottest heatwave per year - yearly maximum of each heatwave peak	degC or degC2 (depending on EHFaccl)
HWM	Average magnitude of the yearly heatwave - yearly average of heatwave magnitude	degC or degC2 (depending on EHFaccl)
HWF	Number of heatwave days - expressed as the percentage relative to the total number of days	days
HWN	Number of heatwaves per year	hw/year
HWD	Duration of the longest heatwave per year	days
HWT	Time of the first heat wave day of the year from 1st month of the year	day
pct	Percentile 90th or 95th over the entire base_period	degC
EHF	Excess Heat Factor index	degC or degC2 (depending on EHFaccl)
HWMt	Average temperature for all yearly heatwave - yearly average of temperature heatwave days	degC
HWAt	Temperature at the peak of the hottest heatwave per year - yearly maximum of each heatwave peak	degC
spell_all	Length of the heatwave in days after the date	days
HWL	Mean duration of heat waves	days

Marine ecosystems are strongly influenced by heatwaves, a kind of extreme climatic events. Marine heatwaves (MHWs), which can be caused by a combination of atmospheric and oceanographic processes, have a strong influence on marine ecosystem structure and function, including mass mortality of abalone, benthic habitat loss and altered human use of the ocean.



Drought Monitoring by Vegetation Indices with Remote Sensing Data

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

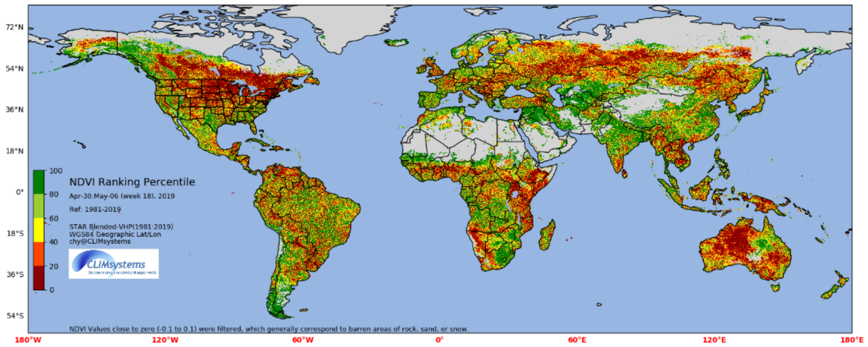
Description

Drought monitoring is an important component in drought early warning systems. Traditional methods of drought assessment and monitoring rely on rainfall data. However, such an approach has two main disadvantages: rainfall data are limited to the region, and they are often inaccurate and difficult to obtain in near-real time.

As we know meteorological droughts have significant impacts on natural vegetation health. Based on satellite remoting sensing imagery, the derived vegetation indicators provide alternative measures of the relative vegetation health, which could be used to monitor the areas where vegetation may be stressed, as a proxy to detect potential drought. Moreover, satellite-sensor data is continuously available.

Based on real-time MODIS and NOAA STAR satellite data, CLIMsystems provide the following indices and products:

- NDVI Anomaly
- NDVI Ranking Percentile
- Standard Vegetation Index (SVI)
- Vegetation Condition Index (VCI)
- Temperature Condition Index (TCI)
- Vegetation Health Index (VHI)



Extreme Wind Analysis Service

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

(1) Generating change factors from GCM data

Climate change data based on CMIP5 GCM daily surface maximum wind speed data. Wind speed probability change for GCM grid cells covering thes tudy region are analysed for each of the listed GCMs. And ensemble 95 percentile of wind speed change (%) for the 26 GCMs, for 2030, 2050, under RCP4.5 and RCP8.5 simulations are selected as the change factors for gust and wind speed assessment under the chosen climate change scenarios.

$$cf_{igcm,s} = (W_{igcm,s} - W_{igcm,his})/W_{igcm,his} \times 100$$

where $cf_{i,s}$ being the change factor of GCM (igcm) for scenario s; in this analysis s include for selected scenarios: RCP4.5, RCP8.5 for 2030 (data range is 2006-2030), 2050 (data range is 2005-2050); W_(igcm,s) being the maximum daily wind simulated by igcm under s scenario. W_(igcm,his) being the daily maximum wind speed simulated by igcm for historical period (1981-2005).

The final ensemble change factors (cf_s) are calculated from the different percentile of 26 GCM ensemble. Various client defined percentiles can be applied, for example, 95 percentile and 75 percentile have been applied by some clients.

(2) Historical observation time series data analysis

Historical daily maximum gust and hourly wind speed records for the nine stations listed in table 1 obtained and validated from NIWA Cliflo (https://cliflo.niwa.co.nz/) for historical probability analysis.

$$Prob_{ih} = \frac{NX_{ih}}{NT} \times 100$$

where NX_{ih} is number of records larger than a thresholds ih; NT being the total number of the records. The historical exceeding probabilities were calculated for the selected threshold (70km/h, 80km/h, 90km/h, and 100km/h).

(3) Apply change factors to historical observation time series data

In the analysis for all stations, each of the maximum gust and hourly average wind speed records was perturbed using the same set of change factors, because they are covered by one GCM grid cell which is normally 100-200 kms.

$$WF_{s,t} = WB_t \times (1 + cf_s)$$

where WF is projected future wind speed (gust or hourly); WB is historical wind speed; cf is the change factor derived from GCMs; s denotes scenar-io; t denotes each wind speed record.

Extreme Wind Analysis Service

Table 2: GCM data availability for climate change impacts on daily maximum wind speed

No.	GCM name	nlat	nlon	No.	GCM name	nlat	nlon
1	ACCESS1-0	144	192	**14**	GISS-E2-R	90	144
2	ACCESS1-3	144	192	**15**	HADGEM2-CC	144	192
3	BCC-CSM1-1	64	128	**16**	HADGEM2-ES	144	192
4	BCC-CSM1-1-M	160	320	**17**	INM-CM4	120	180
5	CANESM2	64	128	**18**	IPSL-CM5A-LR	96	96
6	CMCC-CM	240	480	**19**	IPSL-CM5A-MR	143	144
7	CMCC-CMS	96	192	**20**	IPSL-CM5B-LR	96	96
8	CNRM-CM5	128	256	**21**	MIROC-ESM	64	128
9	CSIRO-MK3-6-0	96	192	**22**	MIROC-ESM-CHEM	64	128
10	GFDL-CM3	90	144	**23**	MIROC5	128	256
11	GFDL-ESM2G	90	144	**24**	MPI-ESM-LR	96	192
12	GFDL-ESM2M	90	144	**25**	MPI-ESM-MR	96	192
13	GISS-E2-H	90	144	**26**	MRI-CGCM3	160	320

Dam Risk Assessment Service

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

Dams as well as protective dikes and levees are critical infrastructures whose associated risk must be properly managed in a continuous and updated process. Usually, dam safety management has been carried out assuming stationary climatic and non-climatic conditions. However, the projected alterations due to climate change are likely to affect different factors driving dam risk. Although some reference institutions develop guidance for including climate change in their decision support strategies, related information is still vast and scattered and its application to specific analyses such as dam safety assessments remains a challenge.

A dam in Myanmar

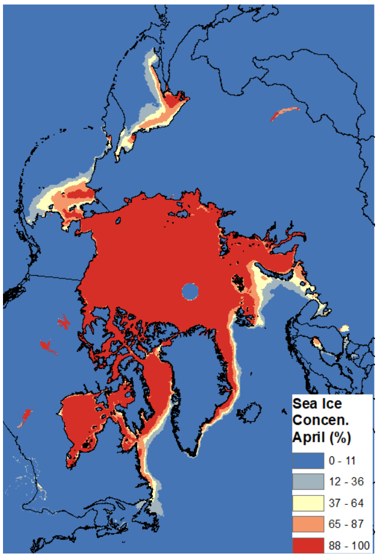
We provide a service to carry out the dam safety assessment by including climate change scenarios and reservoir and dam operational data. Provide recommendation to reduce the risk of dam breaching and maximize the usage of the reservoir water.

Sea Ice Concentration and Extent Assessment Service

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description



Sea ice concentration is both an indicator and driver of high-latitude climate change with strong societal and ecological importance. Sea ice is change fast with climate change, based on state-of-the-art observation data and CMIP5 GCM model output, we provide data services to support the sea ice related assessment. There are 24 CMIP5 GCMs and 5 CORDEX RCMs provided sea ice concentration output. We applied ensemble approach for sea ice change assessment.

Ecosystem Based Approach to Climate Change Risk Reduction

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

Ecosystems such as mangroves, wetland peatland and rangeland play a critical in mitigating and reducing the risks associated to climate change such as storm surges, strong winds, floods and even drought. It is therefore important that these systems are managed sustainably for the communities such as coastal, dryland and urban to reduce their vulnerability to climate change impacts.

In order to mainstream sustainable management of ecosystems they must be valued and their economic values be clearly understood. This involves application of both direct and indirect valuation techniques such as dose response technique, CVM, Travel cost method and marketed based approaches. Through valuation of ecosystems decision makers are able to realise the economic benefits of ecosystem service in climate change risk reduction and invest in their sustainable management.

Economic Analysis of Adaptation Options

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

Climate change will have enormous impacts to a wide range of economic sectors both directly and indirectly. In order to make informed decision to adapt and mitigate the impact of climate change, it is critical that economic analysis is undertaken. This involves Cost Benefit Analysis. In the context of a detailed climate risk and vulnerability assessment, the economic analysis of climate proofing investment projects involves the following key steps:

- assessing the physical impacts of climate change on the project's capacity to deliver services as originally intended—a task requiring expertise of a nature other than economics;
- transforming the identified physical impacts of the climate change into cost of climate change (which may result from an increase in project costs and/or reduction in project benefits);
- assessing the technical feasibility of **alternative project design(s)** or **measures** aimed at offsetting the identified adverse impacts—another task requiring expertise of a nature other than economics;
- estimating the **incremental** costs of these alternative design(s);
- for each technically feasible climate-proofing measure, comparing the estimated incremental cost of the measure with the **expected benefits of the climate-proofing investment**; and
- calculating the (expected) **net present value of each climate-proofing measure**, and making a recommendation.

In this context, a climate-proofing option is defined as an activity aimed at increasing the resilience of the project to climate risk. In economic terms, it is defined as an activity that directly aims at increasing the net present value of the project in the presence of climate change.

It is important to note that climate proofing must imply the consideration of modifications to a project design, such consideration being justified as a result of projected climate change. As such, **climate proofing must imply a positive incremental cost to any given project design (for if a modified "climate-proofed" project design** were to cost less than its "non-climate-proofed" original design and yet deliver the same or higher total benefits, then the "climate-proofed" design should have been preferred in the first place, and thus cannot be considered a response to climate change).

three benefit levels (million USD)

	RCP2.6	RCP2.6	RCP2.6	RCP4.5	RCP4.5	RCP4.5	RCP8.5	RCP8.5
	Benefit sensitivity level (% of USD800M total project investment per degree of w							
	10%	15%	20%	10%	15%	20%	10%	15%
Lifetime 20 years								
Adapt. Cost								
option1 5%	-37.34	-6.14	25.07	-2.60	45.98	94.56	32.69	98.91
option2 10%	-77.34	-46.14	-14.93	-42.60	5.98	54.56	-7.31	58.91
option3 15%	-117.34	-86.14	-54.93	-82.60	-34.02	14.56	-47.31	18.91
option4 20%	-157.34	-126.14	-94.93	-122.60	-74.02	-25.44	-87.31	-21.09
Lifetime 40 years								
Option1 5%	-24.58	16.10	56.78	28.18	95.24	162.31	84.92	180.35
option2 10%	-64.58	-23.90	16.78	-11.82	55.24	122.31	44.92	140.35
option3 15%	-104.58	-63.90	-23.22	-51.82	15.24	82.31	4.92	100.35
option4 20%	-144.58	-103.90	-63.22	-91.82	-24.76	42.31	-35.08	60.35
Lifetime 60 years								
option1 5%	-22.82	19.06	60.95	33.47	103.49	173.52	95.81	197.02
option2 10%	-62.82	-20.94	20.95	-6.53	63.49	133.52	55.81	157.02
option3 15%	-102.82	-60.94	-19.05	-46.53	23.49	93.52	15.81	117.02

Contact CLIMsystems to arrange a call to discuss specific economic analysis applications with our team of experts.

Soil Temperature Analysis Service

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

Soil temperature and snow depth data are derived from a replacement for GLDAS-1 0.25-degree monthly data product. Global Land Data Assimilation System Version 2 (hereafter, GLDAS-2) has two components: one forced entirely with the Princeton meteorological forcing data (hereafter, GLDAS-2.0), and the other forced with a combination of model and observation based forcing data sets. https://disc.gsfc.nasa.gov/datasets/GLDAS_NOAH025_M_V2.1/summary

Availability of GCM variables in the CMIP5 database

	Model	Temp (3 variables)	Precip	SolRad	RelHum	Wind	SLR	Soil Temp	Snow depth
1	ACCESS1.3	•	•	•	•	•		•	•
2	ACCESS1.0	•	•	•	•	•		•	
3	BCC-CSM1-1	•	•		•	•	•		
4	BCC-CSM1-1-m	•	•		•		•		
5	BNU-ESM	•	•					•	
6	CanESM2	•	•	•	•	•	•		•
7	CCSM4	•	•	•	•		•		
8	CESM1-BGC	•	•	•	•				
9	CESM1-CAM5	•	•	•	•				
10	CMCC-CM	•	•	•		•	•	•	•
11	CMCC-CMS	•	•	•		•	•	•	•
12	CNRM-CM5	•	•	•		•	•	•	
13	CSIRO-Mk3-6-0	•	•	•	•	•	•		•
14	EC-EARTH	•	•			•			
15	FGOALS-g2	•	•						
16	FGOALS-s2	•	•					•	•
17	GFDL-CM3	•	•	•	•	•	•	•	
18	GFDL-ESM2G	•	•	•	•	•	•	•	
19	GFDL-ESM2M	•	•	•	•	•	•		
20	GISS-E2-H	•	•	•	•	•		•	•
21	GISS-E2-H-CC	•	•	•	•	•		•	•
22	GISS-E2-R	•	•	•	•	•		•	
23	GISS-E2-R-CC	•	•	•	•	•		•	•
24	HADCM3	•	•	•	•	•			
25	HadGEM2-AO	•	•	•		•			
26	HadGEM2-CC	•	•	•	•	•	•	•	
27	HadGEM2-ES	•	•	•	•	•	•	•	
28	INMCM4	•	•	•	•	•	•	•	•
29	IPSL-CM5A-LR	•	•	•	•	•		•	

Soil Temperature Analysis Service

	Model	Temp (3 variables)	Precip	SolRad	RelHum	Wind	SLR	Soil Temp	Snow depth
30	IPSL-CM5A-MR	•	•	•	•	•		•	
31	IPSL-CM5B-LR	•	•	•	•	•		•	
32	MIROC4H	•	•	•	•				
33	MIROC5	•	•	•	•	•	•		
34	MIROC-ESM	•	•	•	•	•	•		
35	MIROC-ESM-CHEM	•	•	•	•	•	•		
36	MPI-ESM-LR	•	•	•		•	•	•	
37	MPI-ESM-MR	•	•	•		•	•	•	
38	MRI-CGCM3	•	•	•	•	•	•		
39	NorESM1-M	•	•			•	•	•	
40	NorESM1-ME	•	•				•	•	

Snow and Total Annual and Seasonal Snow, Maximum Snow Depth, Continuous Snow Cover and Frequency of Storm Events

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

Snow could be a hazard for energy infrastructure during the winter. The understanding of snow/ice risk characteristics will improve the decision making in terms of risk to the supply of energy and hardening and maintenance of, for example, an electrical grid. Current data supports the modelling of the snow component.

To complete the analysis daily temperature, humidity and precipitation data from various sites within a study area are applied along with weather station historical time series on station snow observations data (hourly from available sites); and, finally Noah 2.7.1 model in the Global Land Data Assimilation System (GLDAS) snowfall and snow melt data (2000-2015), 3-hourly, 0.25 degree (about 20 km) spatial resolution model data will be used.

For Environment Canada data, a snow prognostic method will be applied as follows:

The form of precipitation will be estimated from temperature and humidity using the following equation developed by Koistinen et al. (2004):

$$P_{lp} = \frac{1}{1 + \exp\,(22 - 2.2T - 0.2H)}$$

Where Plp is the probability of liquid precipitation, T (°C) is the temperature, and H (%) is the humidity at a height of 2 m. If Plp $<$ 0.2 precipitation will be considered solid. If Plp $>$ 0.8 precipitation will be considered liquid. In the case of 0.2 $\leq$ Plp $\leq$ 0.8 a weighted combination of these two is used.

GLDAS NOAH data will be applied for snow validation. The records from Environment Canada snow observations sites will also be used for validation purposes.

Freezing Rain/Ice Storms

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

Freezing rain/Ice storm events will be evaluated following a two-step procedure. The first step will be to identify freezing rain events from observation/reanalysis data, while the second will be to convert the precipitation rate into the ice load during a freezing rain event.

The vertical temperature profile is the main determinant of precipitation type. When precipitation particles go through the different temperature stratifications, the temperature and phase state of precipitation particle are mainly affected by the temperatures of warm and cold layers near the surface, as well as the residence time in corresponding stratification. Moreover, the residence time of particle in stratification can be indirectly reflected by the thickness of stratification, which is represented by the difference of air pressure observed at two elevations. This is due to that when a precipitation particle goes through a warm layer, it will absorb heat to either increase its temperature or to be melted. While it goes through a cold layer, it can emit heat to reduce temperature or to be frozen. The amount of absorbed/emitted heat is determined by the intensity of the warm/cold layers. The intensity of a warm layer refers to the area which circled the profile with temperature higher than 0°C and 0°C isotherm, that is, positive energy area (PA). Similarly, the cold layer intensity refers to the area circled by the profile with temperature lower than 0°C and 0°C isotherm, that is, negative energy area (NA). By analyzing the distributions of PA and NA and the relationships between these two values during freezing rain events, freezing rain events can be identified from observation/reanalysis data.

The model proposed by (Jones, 1998) is applied to derive freezing rain ice loads, which is based on the precipitation rate and wind speed.

Extreme Temperature Analysis for Heatwaves and Threshold-based Temperature Changes Service

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

Like the extreme precipitation approach, daily extreme maximum temperature analysis applied GEV analysis using the L-moments method (Hosking and Wallis, 2005). For each GCM, the daily maximum temperature change values are derived directly from the GCM data between 2050 and 2100 and 1986-2005. The 50th percentile of the GCM ensemble for maximum extreme value changes can be applied. For extreme value analysis methodologies please refer to the GCM extreme precipitation analysis section of this compendium for more details.

Design and Upgrading of Airfields: Climate Risk and ESIA Methods and Experience

Host CLIMsystems Ltd
http://climsystems.com/

Contact peter@climsystems.com

Description

Contact CLIMsystems for a comprehensive report of options for airfield risk analyses.

PRODUCTS

SimCLIM 4.0 for Desktop

Host CLIMsystems Limited
http://www.climsystems.com/

Contact soumik@climsystems.com

Description

SimCLIM is a software tool designed to facilitate the assessment of risks from climate change for sustainability officers, consultants, policy makers, academics, non-governmental and governmental organizations and students.

SimCLIM uses the latest CMIP5 climate data. Maps, graphs and charts of various aspects of climate change can be generated spatially and for sites, for cities, provinces/states, nations, and the world. The flexibility of SimCLIM is limitless. Now the power to model past and future climate can be in your hands!

Climate variables (monthly averages)
- precipitation (mm)
- mean temperature (°C)
- minimum temperature (°C)
- maximum temperature (°C)
- on request: solar (W/m2), relative humidity (%), wind (m/s)

Areas (all AR5) GCM and CORDEX RCM data for different domains
- Global (0.5x0.5 degrees; ca. 50x50km) area provided with annual license all countries are available (varying resolution, most 1x1 km)
- some continents are available
- some countries include their states

Functions
- spatial scenarios (given year, emission scenario, climate sensitivity and GCMs, ensemble statistics)
- site specific scenario (given location, emission scenario, climate sensitivity and GCMs)
- site specific sea level rise (with/without Vertical Land Movement)
- site data (import, browse, analytics)
- extreme events (analytics, without/with climate change)

Impact Models
- rain water tank (site specific)
- water balance (spatial)
- coastal erosion (site specific)
- degree day (site specific & spatial)

Links for SimCLIM
- DSSAT, DHI, GIS (export spatial data), Excel, eWater

SimCLIM for ArcGIS/Climate

Host CLIMsystems Limited
http://www.climsystems.com/

Contact soumik@climsystems.com

Description

SimCLIM for ArcGIS / Climate add-in enables ArcGIS users to produce spatial images of climate change through a quick, easy and straight-forward process. The add-in is based on 20 years of development of the standalone SimCLIM tool and uses outputs from global climate models, produced for the IPCC. Both projections of future climate, and changes compared with the baseline climate can be produced.

Climate variables (monthly averages)
- precipitation (mm)
- mean temperature (°C)
- minimum temperature (°C)
- maximum temperature (°C)
- on request: solar (W/m2), relative humidity (%), wind (m/s)

Areas (all AR5) GCM and when available RCM data
- comes with Global (0.5x0.5 degrees; ca. 50x50km)
- can read all SimCLIM2013 areas

Functions
- spatial scenarios (given year, emission scenario, climate sensitivity and GCMs)
- ensembles on the fly
- percentile results for ensembles
- ArcGIS functionality

SimCLIM for ArcGIS/Marine

Host CLIMsystems Limited
http://www.climsystems.com/

Contact soumik@climsystems.com

Description

The SimCLIM for ArcGIS / Marine add-in is the only tool available in the world that gives access to the AR5 marine results. It can help you explore the impacts of climate change on marine biogeochemical cycles, sea level, and sea surface temperature. It is a user-friendly ArcGIS Desktop application launched as a toolbar. It allows you to evaluate uncertainties of ocean warming, offering less time-consuming analysis, and optimizing research costs as well as enhancing current capacity. It has a unique sea level rise dataset, with seasonal variation, including vertical land movement.

Marine variables

- net primary production of carbon by phytoplankton (gC/m3/day)
- dissolved nitrate concentration at surface (mmol/m3)
- dissolved oxygen concentration at surface (mol/m3)
- pH at surface
- dissolved phosphate concentration at surface (mmol/m3)
- total alkalinity at surface (mol/m3)
- dissolved iron concentration at surface (umol/m3)
- dissolved silicate concentration at surface (mmol/m3)
- sea surface temperature (°C)
- sea level rise (cm) with vertical land movement

Areas (all AR5)

- only global (0.25x0.25 degrees; ca. 25x25km)

Functions

- spatial scenarios (given year, emission scenario and GCMs)
- ensembles on the fly
- percentile results for ensembles
- extrapolated global coverage to simplify coast-line alignment
- min/mean/max over the months

Models

- ArcGIS functionality

DSSAT Perturb Tool

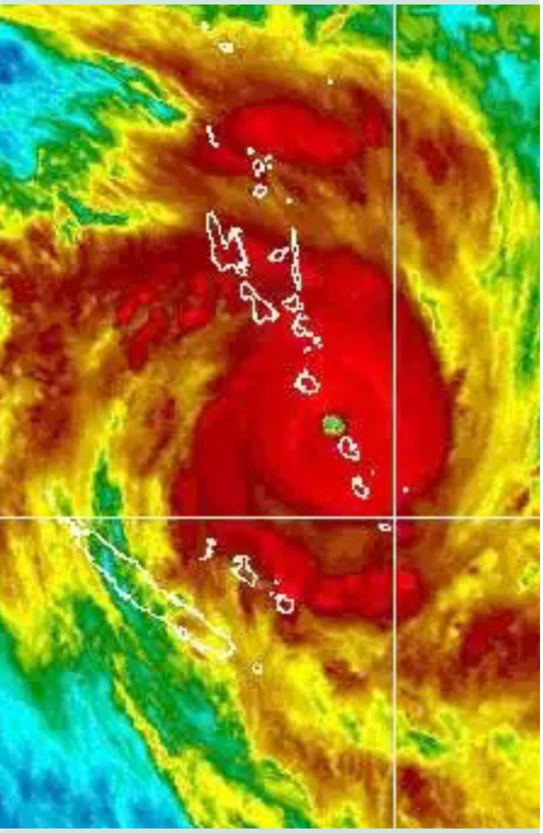
Host CLIMsystems Limited
http://www.climsystems.com/

Contact soumik@climsystems.com

Description

Easily and with scientific rigour, explore future climates against your DSSAT crop files. Simply select your weather file, the Global Circulation Model(s), create an ensemble if you wish to use more than one climate model (highly recommended), choose at representative concentration pathway (RCP 2.6, 4.5, 6.0 or 8.5), your year for analysis (to 2100) and perturb your weather file.

'What if' questions about how crops might respond to a different climate regime while controlling for other variables within DSSAT. For example, you may like to explore how precipitation, temperature and solar radiation may change in your area under a representative concentration pathway (RCP) of 8.5 in the year 2040. You can quickly change one or more of the climate change parameters (the GCMs applied, the RCP, the year) and run another perturbation and rerun your DSSAT model with the perturbed file.



ExtendWeather Sub-seasonal and Seasonal Forecasting

Host CLIMsystems Limited
http://www.extendweather.com/

Contact peter@climsystems.com

Description

Sub Seasonal and Seasonal Forecasting
The sub-seasonal to seasonal timescale provides a unique opportunity to capitalise on the expertise of the weather and climate research communities, and to bring them together to improve predictions on a timescale of particular relevance to the Global Framework for Climate Services (World Meteorological Organisation, 2012).

- Based on Climate Forecast System (CFSv2) data product, ground observations, and remote sensing
- Translate into broad use of the resulting information in decision-making
- Risk based seasonal climate forecasting technologies
- Link with end users' needs and interests, while considering the broader contexts and practical constraints of everyday lives
- Customizable local interpretation and report

Critical climate variables updated every ten days from the latest CFSv2 downscaled model outputs:
- Precipitation anomalies
- Temperature anomalies
- Potential evapotranspiration deficit anomalies
- Wind anomalies
- Other variables available upon request.

Updated Every Ten Days

The team at ExtendWeather ingests global data that is generated four times every day. Every ten days there are 40 global runs that we then process to generate a ten day update of our forecast maps. That means there is an ensemble of 40 model runs we draw upon and then downscale using proprietary methods to generate the high quality five kilometre resolution maps we supply.

Weather Forecasting: Application of GFS Hourly Weather Forecast Data

Host CLIMsystems Limited
http://www.extendweather.com/

Contact peter@climsystems.com

Description

Many web sites already provide weather forecast services using this data. However, most of them only present limited/routine variables such as precipitation, surface temperature at 2m above ground, mean sea level pressure and wind at 10m above ground. Some also present temperature, wind and geopotential height at different pressure levels (such as 250mb, 500mb, 850mb), as well as relative humidity.

Besides these basic variables, we do more:
- Abstract more variables from original forecasts
- Restore multiple-hour average/accumulation variables to be hourly
- Transform variables to meaningful indices

Data source:
- GFS - pgrb2.0p25 (with 0.25 degree longitude-latitude resolution)
- http://nomads.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/
- Model cycle: 4 runs/day at 00, 06, 12 and 18UTC.
- Output Time step: hourly (001~120), 3-hourly (123~384).

Variables, Application Strategy and Examples
At present, 34 variables in total are ready to show on web. It is worth noting that

- Variables in **blue** mean that they cannot be used directly from the original data. A primary processing is necessary.
- Variables in **red** mean that they are calculated from the original data. Advanced processing is necessary.
- Others are extracted directly from the original forecast data files. No processing

1. CAPE - 0~180mb convective available potential energy (J/kg)
2. DPT - Dewpoint temperature (oC)
3. GUST - Gust wind(m/s)
4. LFTX - Lifted Index for thunderstorm
5. MSLP - Mean sea level pressure (hPa or mb)
6. PWAT - Perceptible water (mm)
7. RH - Relative humidity (%)
8. SOILW - 0~10cm soil moisture (%)
9. T2m - Temperature at 2m above ground (oC)
10. T500 - Temperature at 500mb geopotential height (oC)
11. T850 - Temperature at 850mb geopotential height (oC)
12. TOZNE - Total ozone (DU)
13. TSOIL - Ground temperature <10cm (oC)

Continued on next page...

Weather Forecasting: Application of GFS Hourly Weather Forecast Data continued...

14. UV250 - Wind at 250mb geopotential height (m/s)
15. UVGRD_10m - Wind at 10m above ground (m/s)
16. UVGRD_80m - Wind speed at 80m hub height (m/s)
17. ICEC - Sea Ice Cover
18. APCP - hourly precipitation (mm)
19. PEVPR - Potential Evaporation Rate (mm/hour)
20. DSWRF - Downward short-wave radiation flux (W/m2)
21. TCDC - Total cloud cover (%)
22. UVGRD_110m - Wind speed at 110m hub height (m/s)
23. AT - Apparent Temperature (oC)
24. DI - Discomfort Index (oC)
25. ESI - Environmental Stress Index (oC)
26. ETos - Reference evapotranspiration for short crop(mm/hr)
27. ETrs - Reference evapotranspiration for tall crop(mm/hr)
28. HI - Heat Index (oC)
29. HINDEX - Haines Index for wild fire risk
30. Humidex - Humidity Index
31. NET - Net Effective Temperature (oC)
32. NetRAD - Net radiation(W/m2)
33. sWBGT - simplified wet bulb global temperature
34. THI - Temperature Humidity Index
35. THIC - Temperature Humidity Index Comfort
36. THIP - Temperature Humidity Index Physiology
37. WBT - Wet bulb temperature (oC)
38. WCI - Wind chill temperature (oC)

SERVICES

Sub-hourly to Multiple Day Extreme Rainfall Analysis Service

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

To assist our clients to better understand the implications of data and methods to extreme rainfall events analysis we have put together the following matrix and links to more detailed information. After digesting some or all of this information sometimes a quick call is helpful to further refine your specific methodological requirements.

- Proprietary climate change projections based on downscaled sub-hourly to daily GCM/RCM output
- Multiple distributions fitting and testing
- Multiple station/duration regional analysis
- Bootstrapping confidence intervals
- Intensity density function chart generation
- Time series analysis utilities
- High quality outputs for application in future design storm modelling

CLIMsystems developed an innovative hybrid approach to perturb 5 to 15 minute rainfall time series data. The approach better reflects the climate change signal projected in GCMs and RCMs, including extremes, variation and total amount of change in precipitation that can be applied either for a locale or spatially. There are several key factors accommodated in the approach that are important: (1) the method must preserve the extreme precipitation change information in the climate model (perturbed) output, especially the Intensity Duration Frequency (IDF) change characteristics; (2) the changes in non-extreme precipitation Cumulative Distribution Function (CDF) distribution in all quantiles must be retained; and, (3) the changes in annual and monthly precipitation must be retained. The approach devised and applied by CLIMsystems meets these three criteria.

Drought Monitoring and Analysis Service

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

Based upon precipitation and potential evapotranspiration data, an SPEI approach has the capacity to include the effects of temperature variability in drought risk assessments. SPEI is based on a water balance. The SPEI uses the monthly (or weekly) difference between precipitation and PET (Potential Evapotranspiration). A serially complete data set of both temperature and precipitation (daily, weekly or monthly) is needed to calculate the SPEI. The results of an SPEI calculation are represented as positive (wetter than normal) and negative (drier than normal) conditions.

Main functions of Drought Assessment Tool include:
- Spatial Calculation
- Time slice extraction from long term spatial data
- Spatial data visualization
- Spatial data animation (movie maker)
- Single station calculation
- Single station data plotting
- Site specific calculation

Output variables
- Precipitation (input data, unit: mm)
- Potential evapotranspiration (input data, unit: mm)
- Soil Moisture Index (input data, -150.0---150.0 unit: mm)
- SPI Standardised Precipitation Index (output: value range -3.0 to +3.0)
- Standardised precipitation evapotranspiration index (output, value range -3.0 to +3.0)
- Standardised Pasture Growth Index available (output: value range 0.0 to 1.0)

SWAT and Water Resources Modeling and Data Service

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

The Soil Water Assessment Tool (SWAT) is an integrated watershed model widely applied across the world to study hydrology, sediment, in-stream water quality, the impact of land use, climate change and various water management interventions on water quantity and quality.

According to our training experience around several countries, we identified a complete toolchain useful to train hydrological modeling under climate change.

ArcSWAT

ArcSWAT is an ArcGIS-ArcView extension and graphical user input interface for SWAT.

SWAT-CUP

SWAT-CUP is a calibration/uncertainty or sensitivity program interface for SWAT, which links SUFI2, PSO, GLUE, ParaSol, and MCMC procedures to SWAT. It enables sensitivity analysis, calibration, validation, and uncertainty analysis of SWAT models. SWAT-CUP also has graphical modules to observe simulation results, uncertainty range, sensitivity graphs, watershed visualization using Bing map, and statistical reports.

SimCLIM-SW

SimCLIM-SW is a plugin of the climate data management software of SimCLIM, which applies the simple Delta approach to perturb daily/month weather data to take GCM/RCM projections into account to assess the impact of climate change on the hydrological processes.

SWAT Output Viewer

SWAT Output Viewer is a tool to quickly view and analyze the outputs of a SWAT model on-the-fly.

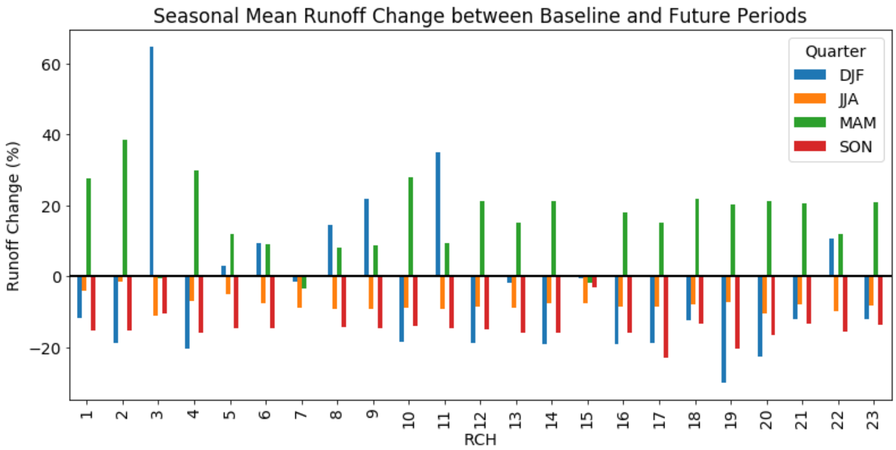
SQLite Expert

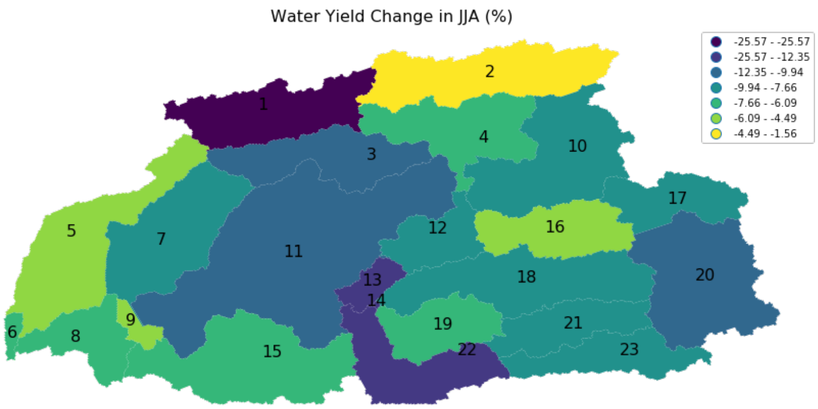
In fact, the SWAT Output Viewer reread and then save the SWAT simulation into a SQLite3 database. As is the case, SQLite Expert-like software could be used to query and summarize the SWAT simulation if familiar with the SQL language. Or the SWAT simulation can be exported to other formats such as .xlsx and .csv, etc.

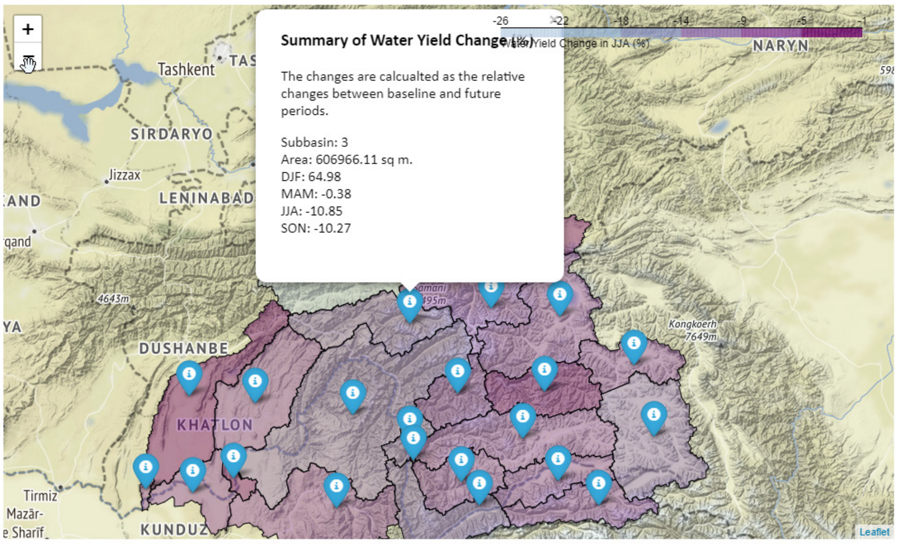
Jupyter Notebook

It is easy to use Python to pull down the summarized data to further process on the client side in Python, or to merge with data from other sources using familiar Pandas data structures. Jupyter Notebook is a good tool for interactive programming and visualization.

SWAT and Water Resources Modeling and Data Service







Sea Level Rise and Extreme Sea Level Analysis Service

Host CLIMsystems Limited
http://climsystems.com, http://slr.climsystems.com

Contact peter@climsystems.com

Description

The sea level rise data is based on the Fifth Assessment Report of the IPCC and expresses the value in 2100 applying an ensemble of 28 general circulation models (GCMs) with all RCPs and sensitivities possible for analysis. All the sea level/climate data has been processed following Intergovernmental Panel on Climate Change (IPCC) guidelines.

Extreme sea levels analysis tool includes the latest historical storms surge data for the globe, high tide events, and sea levels changes caused by lower atmospheric pressure and severe winds during storms in climate scenarios.

Climate Change Scenario and Baseline Data Generation

Host CLIMsystems Limited
http://www.climsystems.com

Contact peter@climsystems.com

Description

- High resolution spatial climate change scenarios, based on public available GCM or RCM data or customer provided climate change model data.
- High resolution baseline data according to user provided historical observation data or publicly available data.
- GIS compatible format and SimCLIM format

GCM Daily Data Bias Correction and Spatial Downscaling Service

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

The bias corrected daily GCM data can be used as the input for hydrological modelling, such as SWAT, and crop modelling, such as DSSAT, or other models needing **daily climate change scenario data as input**.

An equal distance-based CDF mapping method (EDCDF) is applied to correct the daily time series of precipitation and temperature data from GCMs based on historical station observation or gridded data. This method was different from the traditional method in that the information from the CDF of the downscaled projection was also incorporated into the BC procedure. The innovative method has been applied successfully in a number of projects.

Dust Haze and Sand Storm Modelling

Host CLIMsystems Limited
http://www.climsystems.com

Contact peter@climsystems.com

Description

The physical generating mechanism of dust and sand storms is very complex. They should meet three requirements: source of sand, strong wind, and an unstable structure of the lower atmosphere. We apply a hybrid model that combines an adaptive synthetic (ADASYN) sampling approach (He, et al., 2008) and decision forests (Wang et al., 2013) as they contribute a reasonable solution to the problem of rare classes' classification. The ADASYN is an extension of SMOTE (Synthetic Minority Oversampling Technique), creating more examples in the vicinity of the boundary between the two classes, than in the interior of the minority class. The model is operated on monthly steps.

The indexes of monthly average wind speed, frequency of maximum wind, monthly average temperature, precipitation, monthly average relative humidity, and monthly average air pressure are selected as predictors, while frequency of total dust haze and sand storm occurrence in the given month is selected as predictant of forecast (1984-2015).

Heat Index

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

There are at least 30 published methods for computing heat stress. All require different types of data and at various temporal resolutions. The humidex method is explained here but other indices can be applied that reflect client needs. It is acknowledged that different methodologies allow for different interpretation of impacts such as from solar radiance and wind. Limitations on data at the study location need to be considered when choosing a method for application.

The Humidex Index is calculated based on the current temperature and the dew point (Masterson and Richardson, 1979). A dew point temperature is when humid air is cooled enough for water vapour (gas) to become water (liquid). The dew point is related to the relative humidity level. At high humidity levels, the dew point is close to the current air temperature because the air is nearly saturated with water vapour. At low humidity levels, the dew point is much lower than the current temperature. The dew point can be calculated from the air temperature and the relative humidity. At the same time, the relative humidity can be derived from the air temperature and the dew point. Therefore, either the dew point or relative humidity can be calculated when the other is known along with air temperature.

Blended Weather File with Climate Change for Infrastructure Design

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

In order to design a climate proof and energy efficient infrastructure in the climate changing world, detailed historical weather data need to be blended with climate change factors.

A morphing algorithm is used to mathematically transform historical weather data to produce future weather files for use in building simulations (Belcher et al., 2005). Weather data from the baseline period 1984 – 2014 are mathematically transformed using monthly estimates of climate change available from the CIMP5 GCM data archives (http://cmip-pcmdi.llnl.gov/cmip5/) and from WCRP CORDEX RCM data archives (http://www.cordex.org/). The basic underlying process for the morphing of the weather files consists of two different algorithms depending on the parameter to be morphed.

Climate and Asset Risk Assessment Service

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

Risk management has become an integral part of good asset risk management practice. It is reaffirmed by the trend towards industry leading practices and standards that have emerged. With ISO55000, asset management now has own International Standard, which can be seen as a real milestone in recognition of asset management as a fully-fledged discipline.

The full potential of quantitative risk assessment is not yet explored although it can bring huge benefits to an organization.

CLIMsystems has a fully developed methodology and reporting matrix that can include any of the following with each asset analyzed as a discrete case:

- Mean temperature
- Extreme heat with days > 35 C
- Annual rainfall
- Extreme daily rainfall
- Sea level rise (SLR) for coastal assets
- Extreme rainfall sub-daily (applied in assessing roof and roof drainage design)
- Rainfall intensity, duration, frequency analysis (applied in design of drainage requirements)
- Daily rainfall distribution (magnitude and frequency) in relation to rain water collection designs
- Degree day calculations (applied in assessing cooling requirements for air conditioning and changes in length of cooling/heating season)
- Change in Solar Power Potential (from climate change)
- Forest Fire Danger Index (FFDI) for bushfire risk analysis

Results are provided in a tabular format. A summary table (simplifying the comparison between the assets) is also included. Historical incidents images of hail, wind and tornados can be provided to illustrate the potential risks of these hazards to the assets for sites where such data is available.

Dashboards with maps and charts can also be generated.

Urban Forestry as a Mitigation and Adaptation Measure

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

The WRF/NOAH-MP model can be customized and applied in combination with other models including the UrbanCLIM/RIDS system developed by CLIMsystems/IGCI. UrbanCLIM/RIDS is a modelling system designed for urban planning and design making (http://www.igci.org.nz/rids/). Other model system such as ENVI-met (http://www.envi-met.com/), a software system that focuses on microclimate simulation could also be applied where it is required.

Several reafforestation plan scenarios can be analyzed:

- Aim of the plantation and if single or multi-purpose, different type of tree species;
- Approach wanted to cover the area identified, i.e., plant total area or phased approach, e.g., on an annual basis;
- Assessment of climate change impact on different plantation plans;
- Assessment of the benefits, including indirect benefits, identified costs for establishment and maintenance.

The key output of the assessment of different planning scenarios will include but not limit to:

- Urban heat island effect change
- Human Comfortable Index (City Micro-climate)
- Hydrological change and flood drought risk reduction (Adaptation)
- Carbon storage and sequestration rate (Mitigation)
- Cost and benefit analysis (Climate change economics)

Integrated scenario-based cost benefit assessment:

- Potential link with water system model for water management.
- Adaptation (risk reduction): runoff, soil and water conservation, heat island effect reduction.
- Mitigation: forest can have various sequestration rates depending on its composition and the mitigation effects can be vary.
- Urban environment improvement microclimate: reduce urban heat island effect, comfort index.
- Potential risk reduction: drought and flood.
- Recommendations on plantation plans and corresponding climate and hydrological effects.

The Infrastructure Planning Support System (IPSS)

Host Resilient Analytics in Partnership with CLIMsystems Ltd
http://www.resilient-analytics.com/pages/ra-ipss_en.html
http://climsystems.com/

Contact peter@climsystems.com

Description

The justification for engaging Resilient Analytics and CLIMsystems to perform climate vulnerability and resilience analysis comes down to:

Is this asset project being designed to historic and obsolete norms, or is this project being designed to future conditions that will be the actual operating environment?

Can in-place assets be assessed for climate risk and be retrofitted to reduce that risk?

Resilient Analytics ensures that both retrofitting and design and planning decisions focus on the future operating environment and are supported with the most advanced climate science provided by CLIMsystems and engineering input to minimize the opportunity for near-term and long-term financial regret. Resilient Analytics provides this support through the following set of key objectives:

- Support infrastructure development through forward-looking engineering considerations critical to design and systems performance.
- Support resilient design strategies through robust, climate-based risk management and decision support.
- Complement existing vulnerability-reduction and resilience-enhancing policies by considering key changes in extreme events frequency and severity.

The inclusion of these objectives provides project developers with the assurance that project designs are considering the latest projections of climate impact that could increase the construction and/or operations costs. In fiscal terms - engaging Resilient Analytics supports the fiduciary responsibility that a project team has to the project owners and developers.

A risk-based approach to adaptation is not only desirable but also practicable. It combines both the likelihood and consequence components of climate-related impacts and can assess risks for both current and anticipated conditions, with the option of examining either specific events or an integration of those events over time. Furthermore, risk assessment and management are common to many sectors and asset classes - e.g., health, financial, transport, agriculture, energy, and water resources. The existing familiarity of planners and decision makers with risk management therefore helps facilitate the mainstreaming of risk-based adaptation. Risk-based methods also facilitate an objective and more quantitative approach, including cost benefit analyses that result in evaluation of the incremental costs and benefits of adaptation and assist in prioritizing adaptation options.

Climate Change Data API

Host CLIMsystems Limited
http://www.climsystems.com/

Contact peter@climsystems.com

Description

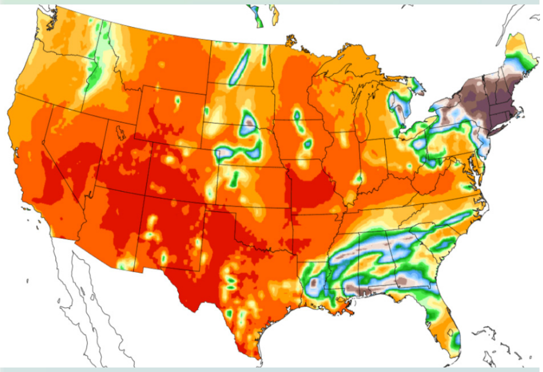
CLIMsystems has carried out the first order data availability assessment for 13 climate related variables and 18 standard indicators applied in various Asset-Risk Analyses. The latest CMIP5 data has been or is being post-processed for the climate variables. There are multiple sources for acquiring relevant public data for socio-economic indicators. The data sources, usefulness, and potential sub-indicator need to be further investigated, screened, and refined in collaboration with end users as a next stage.

CLIMsystems can provide unique climate change vulnerability assessment information using more sophisticated data and methodologies to subnational scale which will be very helpful for project planning and implementation.

CLIMsystems has instituted an API for delivery of data. It permits the rapid access to a range of global data that is prepared and populates a database and then is queried for extraction of data specific to a site depending on the type of data available. The API can be augmented with new data and refreshed data sets as they either become available or based on end user demand.

Prices for data credits can vary considerable depending on the type of variables queried. Please when appropriate discuss data needs and potential costs with CLIMsystems prior to price setting with potential third party clients with whom you will be applying the data outputs

CONSULTING



Green Climate Fund: Processes enabling access to climate finance

Host CLIMsystems Limited
http://www.climsystems.com/

Contact wayne@climsystems.com

Description

CLIMsystems can assist with all aspects of accessing the Green Climate Fund Readiness Financing stream. We can advise on development of proposals and assist with implementation of the readiness activities.

Introduction

The following information is a simplified outline of the main components of how to access climate finance through the GCF. While the GCF itself provides diagrams and flow charts to assist countries understand their processes often this creates some confusion, particularly with regards to timelines. There are two separate components to GCF financing, Readiness Funding and Full Project Financing.

Readiness Funding

Eligible countries (All Developing Country members) need to gain accreditation by identifying a National Designated Authority (NDA) and will have submitted an Indicative Nationally Determined Contribution (INDC), and signed off on the Paris Agreement on Climate Change.

Key Features	Key Features
A concept proposal required, up to 3 months for an approval from GCF, set times during calendar year NDA/Government can use technical expertise with experience to prepare and undertake Readiness Activities	A maximum of US$1 million available per country but only US$300,000 available for awareness and NDA capacity development, additional amount possible. Readiness funding also covers National Adaptation Plans for which there is US$3 million maximum available.
Key focus of Readiness Funding is: • Raising awareness of GCF and processes for all stakeholders (not only government officials • Institutional strengthening of the NDA, and to assist any departments/ministries with their project prioritisation • Builds effective coordination by supporting existing government coordination mechanisms at all levels, Federal, State, and key civil society participation	Requires government approval to submit the proposal, through the NDA Can use existing accredited agencies or support agencies to become accredited with GCF and become involved in project developments over a longer term. Promotes sub-national participation Encourages Private Sector participation

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Green Climate Fund: Processes enabling access to climate finance continued

Key Features	Key Features
Sets up processes and consultations in-country for large scale project developments, incl financing in key development sectors	The first step toward seeking "seed funding for project investments
Often takes up to 12 months to complete all activities proposed	Key Outputs need to be: • Raised awareness about the GCF amongst all stakeholders not just government • Builds transparent coordination group (eg, a Climate Change Committee) that can have input into projects and their development • Identifies priority projects as an "investment plan" looking forward

Based upon the performance and outputs of the Readiness Fund activities, a government may then be in a position to work on a full scale larger project/program. A full project concept goes through a much larger assessment and consultative process within a set of key steps.

Dependent on who is selected to assist in the full scale project development there are a range of criteria placed upon Accredited Entities, such as scale of funds they are approved to develop:

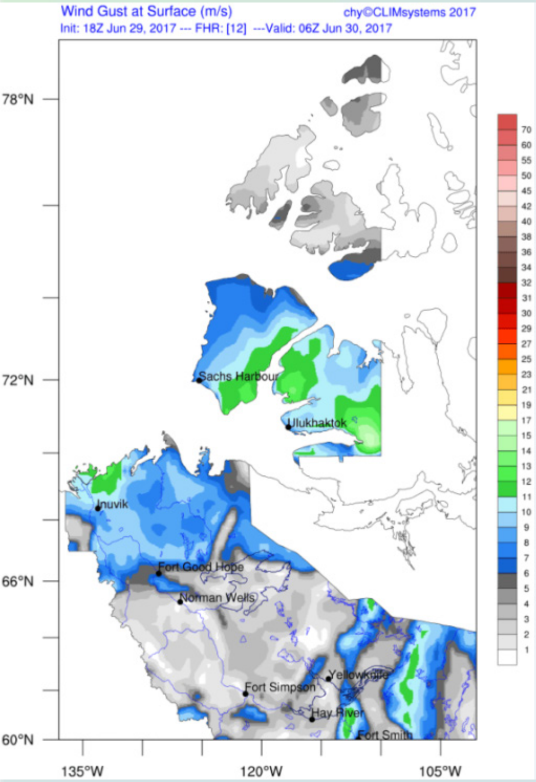
Micro - for projects with total projected costs up to US$10 million
Small - for projects with total projected costs of between US$10 million and US$50 million
Medium - for projects with total projected costs of above US$50 million and up to US$250 million
Large - for projects with total projected costs of above US$250 million.

Accredited Entities are Organisations who have received approval to directly access GCF funds. There are currently 238 that are seeking accreditation. Some have approval to manage GCF funds for countries. All funds are not grants aside from Readiness and smaller amounts within the project development process.

Other criteria for Accredited Entities cover the types of activities they are approved to undertake, such as project management, grant based funding access only, and on-lending.

A risk category is also associated with project developments, such as irreversible risk, small to low risk, and little or no risk. Details on all of the above should be highlighted and discussed during the Readiness Funded Phase, as a part of awareness raising on the GCF to all stakeholders with an interest to participate in GCF funding.

GCF finances cover, national, sub-national, and key stakeholder involvement and access via the NDA in-country.



Green Climate Fund: Preparing for a Long Term National Adaptation Plan

Host CLIMsystems Limited
http://www.climsystems.com/

Contact wayne@climsystems.com

Description

CLIMsystems Ltd has staff experience across a range of sectors that is supported by excellent data, tool and community development services. CLIMsystems partners with countries and other institutions to generate high quality risk assessments and priority plans for adaptation funding that are comprehensive in that they can cover from national to local scale and apply the latest risk science.

What is a long-term approach and how often is this planned as a part of any project design? Infrastructure type projects with “hard” structures are readily definable as each has a defined lifetime, such as a bridge with a 50 year or more lifespan. But often the reality is that programs are developed which fit within the policies, procedures and measures of the support or assistance organisation providing the finances. In other words, to fit administratively, to a set of rules. Previous attempts at changing such rules have often met with stiff resistance and challenges. The GEFs programmatic approach started to look at these issues, but from a country point of view not the donors, and many country’s felt this was a way to place limits and restrictions on use of funds, at the time.

A long-term approach to addressing climate change, which, in itself is long-term, requires the building of a framework, that brings together all of the key facets needed to develop solutions to the problem. Current short and even medium term projects are often found to not be as effective as envisaged, or perform poorly, and even though project design and implementation are often seen as the issue, longevity is also a critical factor to success. An example of capacity building highlights the very issues that are financed but continually provide some if the biggest challenges in the developing countries today. Leakage exists within the capacity building context because as humankind is upskilled they will often wish to further their own careers and their family’s situation. Addressing this issue has not be done effectively under most programs within the climate change arena. A NAP in the longer term could provide possible solutions toward minimising this issue.

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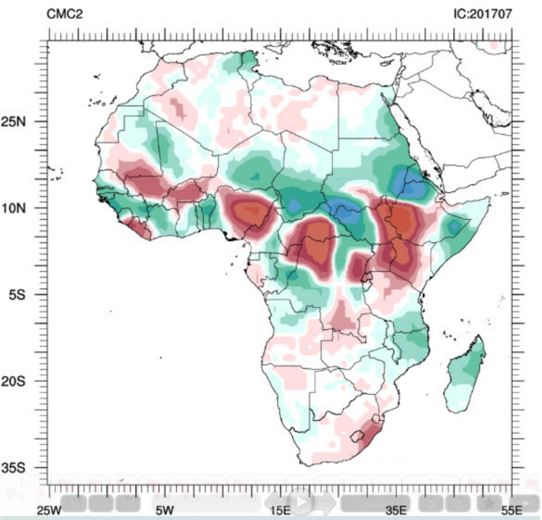
Green Climate Fund: Preparing for a Long Term National Adaptation Plan continued



What would a long terms NAP look like or what are the key prerequisites needed:

- Be a minimum of 20+ years and is a Programmatic Approach rather than project focused
- Will still require regular reviews, but for well-designed programs, may be similar to current strategies and reviews, and be undertaken at 5 yearly intervals, and overcome the administratively burdensome M&E processes currently used
- During the early design stages focus is on Accessing Climate Finances and Private Sector Wealth Creation, but during implementation would not occupy such importance if development partners are a part of the design process
- Emphasises and improves Donor Coordination by establishing a mechanism where status of activities, interest areas, and financing, can be discussed to ensure the beneficiaries are not involved in duplication of efforts, fragmented approaches by separate agencies, etc
- A long-term NAP would provide improved certainty to the Private Investor through the development of an investment pipeline that is wrapped around the range of other critical areas that are needed for an overall successful long-term program, such as government commitment, enhanced capacity building, economic incentives to provide assistance, a good rate of return on investment, among others.
- Conversely the same would hold true for general society where key sector growth certainty (such as in Agriculture and Water Resources) will decrease anxiety, increase well-being over time, and increase resilience to a changing climate.

For an overview of staff and project experience see the links below:

http://www.climsystems.com/about/meet-the-team/
http://www.climsystems.com/whats-new/activities/