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Climate

monitoring and research

Vaisala contributes to Earth's climate knowledge

Climate change is a pressing scientific problem and a major societal and political challenge worldwide. The need for an accurate, precise and representative record of atmospheric changes is fundamental to all facets of the climate debate.

Over the past 130 years, the Earth's surface has warmed at an alarming rate – about 0.9°C (1.6°F) when averaged over the global oceans and land masses. As a consequence, sea level is rising, glaciers are retreating

and the extent of Arctic sea ice is shrinking. Nations are seeking to respond with effective and affordable mitigation and adaptation strategies.

Fundamental to all facets of the climate debate is the need for an extremely accurate, precise and representative record of atmospheric changes – especially temperature, water vapor and precipitation, which need to be measured over multi-decadal timescales and on geographical scales ranging from local to regional and global.

On the climate forcing side, the record must include the amount and distribution of greenhouse gases (GHGs) such as carbon dioxide (CO₂), methane (CH₄), water vapor, chlorofluorocarbons (CFCs) and sulfur hexafluoride (SF₆), the changes in solar forcing, anthropogenic GHG emissions and natural particulate emissions from volcanic eruptions, as well as carbon fluxes from biomass burning, to cite just a few.

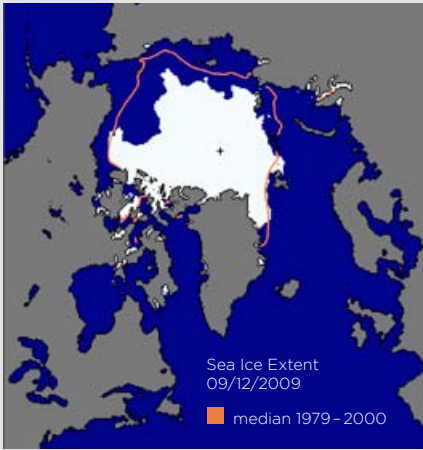
As part of its corporate social responsibility commitment, Vaisala is developing new and improved measurement devices and systems to help meet the special needs of the long-term climate record – a climate reference radiosonde, a truly global lightning detection network,

affordable in situ CO₂ sensors, and an improved precipitation gauge.

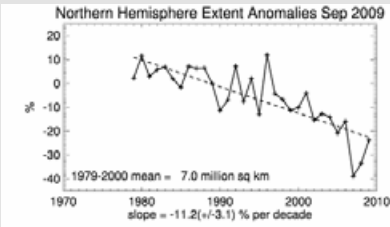
Climate reference radiosonde helps assess climate change

In 2007, the World Meteorological Organization's (WMO) Global Climate Observing System laid out the need for a Global Reference Upper-Air Network, or GRUAN. They concluded (WMO, 2007) that shortcomings in the current upper-air measurement network do not satisfy the accuracy and detail of observations needed to specify climate variability and changes above the Earth's surface. This deficit greatly impacts the ability to accurately assess and predict climate change, and hence has potentially serious consequences in areas of high relevance to society.

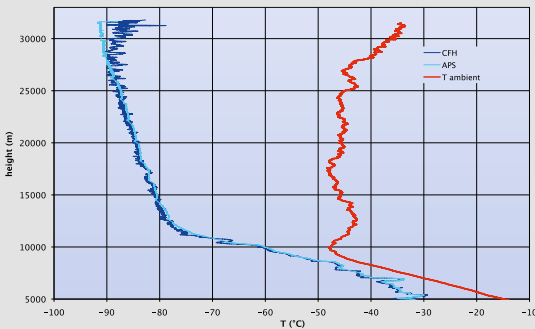
The overall goal of GRUAN is to establish 30–40 stations that will use reference grade radiosondes in addition to other instrumentation to represent climate around the world (Seidel, 2009). While the current radiosondes support normal weather observation needs well, they do not provide sufficiently accurate information for climate and climate-change needs. An improved radiosonde is



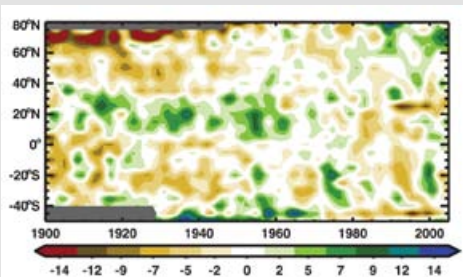
National Snow and Ice Data Center, Boulder, CO



Arctic sea ice extent for September 12, 2009 (the estimated annual minimum for the year) compared with the median extent for 1979–2000. Also shown is the trend in annual minima for 1979–2009. Source: National Snow and Ice Data Center, Boulder, Colorado.



Upper atmosphere humidity (frost point temperature) measured with Vaisala APS sensor and CFH, a state-of-the-art chilled mirror hygrometer. Ambient temperature is also shown. Sounding was done at Sodankylä, Finland on July 17, 2007. (Balloon borne chilled mirror hygrometers are considered the most accurate instruments for upper atmospheric humidity measurements, but are too expensive and complicated for routine soundings).



Latitude-time section of zonal average annual anomalies for precipitation (% average departure) over land from 1900–2005 relative to their means from 1961–1990. Gray areas indicate missing data. (Trenberth et al. 2007.)

needed to meet GRUAN’s upper-air climate requirements of precision and accuracy.

Water vapor is the most abundant and most important greenhouse gas in Earth’s atmosphere. However, it is also one of the most difficult parameters to measure with high precision and accuracy, especially in the upper troposphere and stratosphere where conditions are extremely cold and dry. Therefore, the program is focusing initially on improved upper-air measurements of humidity.

In January 2009, Vaisala launched an internal program to develop an operational reference-grade radiosonde that could be used in GRUAN and other applications where enhanced radiosonde sensor performance is required. The program is being implemented in close collaboration with the meteorological research community, and the benefits will be shared equally with all countries.

The first version of the operational reference radiosonde is based on the Vaisala Radiosonde RS92 sensors and Vaisala’s Advanced Polymer Sensor (APS), a new capacitive sensor capable of measuring extremely low dewpoints. The APS is designed to observe humidity at altitudes to 30 km. It has dewpoint range from -30°C to -90°C , thus supplementing well the conventional RS92 sensor by providing an independent humidity measurement.

Following internal field trials, external testing began in autumn

2009 in cooperation with several international research partners. The first test results were reported at the Annual Meeting of the American Meteorological Society in January 2010 (Turtiainen et al., 2010).

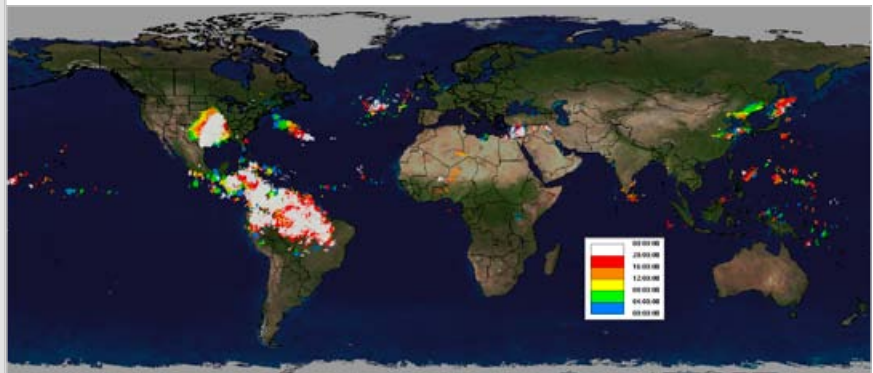
In parallel with field testing of the APS, the program is also proceeding to develop and test more precise measurements for other atmospheric parameters. Development will continue until the climate science needs (including lower tropospheric requirements) are satisfied for humidity, temperature, pressure and wind soundings.

Global lightning activity vs. convective precipitation intensity

Global lightning data offer great promise for monitoring the impact of climate change on regional-to-global scale convective precipitation and possibly even temperature. Global lightning data also enable climate scientists to study the relationship between regional and larger-scale patterns, thus facilitating the development and evaluation of climate downscaling methodologies.

Although a high performance global lightning dataset did not exist until 2009, regional differences in lightning activity have been found during recent warming in the tropics (Petersen and Buechler, 2008). Pessi and Businger (2009) recently reported on a strong relationship between lightning rates and convec-

Lightning detected by Vaisala’s GLD360 for the 24-hour period ending at 00 UTC 30 October 2009.



tive rainfall rate over the North Pacific Ocean, which may be further applied to examine changes in convective precipitation frequency and intensity associated with climate change. Changes in global lightning frequency have also been proposed as a possible proxy for global temperature change (NRC, 1998).

Historically, the creation of a high performance, accurate, and reliable global lightning dataset has presented a substantial challenge to the lightning detection and research communities. Vaisala, however, made a major breakthrough in this area through collaboration with Stanford University, which enabled the deployment of the Global Lightning Detection Network (GLDN).

The GLDN consists of a number of sensors strategically placed around the world for optimal detection of cloud-to-ground (CG) lightning strokes. These wideband sensors detect CG lightning using magnetic direction finding and time-of-arrival methodologies combined with proprietary lightning recognition algorithms in the VLF (Very Low Frequency) band. Signals captured by these sensors are transmitted to Vaisala's Network Control Center (NCC) in Tucson, Arizona where they are combined with other sensor data to optimize the location estimate of the CG stroke.

Derived from the GLDN, Vaisala Global Lightning Dataset GLD360 is a high performance, accurate, and reliable dataset that provides an opportunity for the climate community to continuously monitor relationships between climate change and regional-to-global scale lightning activity and convective precipitation.

CO₂ monitoring facilitates the study of soil respiration

There are several methods for measuring the exchange or flux of CO₂ between terrestrial ecosystems and the atmosphere, the most common being the eddy covariance

method. While the eddy-covariance method measures net ecosystem production resulting from photosynthesis and respiration, it cannot provide unique information such as autotrophic and heterotrophic respiration.

Soil respiration is a major component of the terrestrial carbon cycle, constituting up to approximately three-quarters of the total ecosystem respiration (Law et al. 2001). Soil CO₂ measurements are needed to better understand soil gas processes and their eventual impact on climate.

Soil respiration has been traditionally studied using the chamber based method; however the soil CO₂ vertical gradient method, where CO₂ probes are buried at different depths in the soil, is becoming increasingly popular (Tang et al. 2003, Pumpanen et al. 2008, Pingingtha et al. in press). The gradient method is valuable for clarifying how the CO₂ flux from the soil to the atmosphere varies with season, light conditions, temperature, moisture, and soil properties. It is especially useful in arctic and boreal regions where snow cover lasts for several months, making it difficult for chamber based measurements.

Vaisala manufactures the only CO₂ measuring instruments that can be buried in the soil. The probes use silicon-based, non-dispersive infra-red (NDIR) Vaisala CARBOCAP® sensors for the measurement of CO₂. Their working principle – single-beam dual-wavelength NDIR – is the same method used in expensive high-performance analyzers. However, the traditional rotating wheel is replaced with a tiny, electrically controlled Fabry-Perot Interferometer.

In situ monitoring provides data on precipitation patterns

While temperature change is perhaps the most obvious indicator of climate change, patterns and intensity of precipitation vary as well. Differences in radiative forcing affect the

heating of the earth's surface and consequently also evaporation and sensible heating. In addition, higher temperatures enable air to hold more water vapor. As a result, precipitation patterns have changed in many regions of the globe over the past century (Trenberth et al. 2007).

Figure on page 6 shows zonal anomalies in precipitation observed from 1900 to 2005. In the extreme northern latitudes, upward trends have been detected as indicated by negative anomalies in the early 1900s and positive anomalies in the late 1900s and early 2000s. By contrast, downward trends are seen in the subtropical regions of the northern hemisphere.

Climate scientists have focused on quantifying regional precipitation patterns because of the difficulties in obtaining accurate and representative precipitation measurements, especially over remote land and oceanic regions as well as during snow and ice events. These challenges underscore the need for quality instrumentation and careful network design. Accurate and reliable datasets with broad geographical coverage will enhance our understanding of the changes in precipitation patterns that accompany climate temperature changes.

Vaisala's All Weather Precipitation Gauge VRG101 and related accessories have been designed for remote automated measurement and to withstand icy, snowy and freezing conditions. For example, the Kentucky Mesonet in the USA utilizes the VRG101 as the primary precipitation measuring device at each of its 37 mesonet stations.

The text is abridged from an original article first published during the United Nations Climate Change Conference in Copenhagen last December. The full text including references can be accessed online at www.vaisala.com/vaisalanews.