Weather outlook for 2014/15 in the light of Climate Change

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CONTENT

- Namibia within a global atmospheric circulation system and HEAT as a driver for global atmospheric flow;
- The Namibian climate: Rainfall and temperature;
- Modelling of the atmospheric system;
- Experimental design for our climate simulations;
- Earth’s radiation budget and Representative Concentration Pathways (RCPs) for greenhouse gasses;
- Future projections of near-surface temperature and rainfall / latest outlook for 2014/2015;
- Conclusions

The atmosphere behaves like a fluid with components of chaos in its propagation. However, atmospheric mass (and therefore flow) is partially modulated by forces:
- Gravitation
- T & P gradients
- Rotation
- Friction and others

The influence of such forces results in some identifiable flow patterns or distinct rainfall zones.

Satellite images:
January 2014, 12:00
University of Dundee – Satellite Receiving Station
www.sat.dundee.ac.za

Planetary-scale atmospheric flow is considerably modulated by two drivers or forces:
- Temperature gradients between the equator (higher T) towards the poles (lower T), as a result of surface HEAT radiation gradients. More heat radiation at the equator results in lower surface pressures which initiate surface flow from higher pressures regions (convergence). This leads to convection at the equator and subsidence at the poles (Hadley Circulation).
- The rotation of the Earth, at one revolution in 24-hours, results in a surface velocity gradients from the equator (higher surface velocities) towards the poles (lower surface velocities).
PLANETARY-SCALE atmospheric flow is characterised by convection (lift of air mass) at equatorial regions (in reality above the HEAT equator) associated with easterly flow. As a result, South Africa is located at the DRY subtropics that is associated with subsidence from the upper atmosphere, with increased surface westerly atmospheric flow to the south.

Continental HEAT (Sensible Heat Flux – shaded in W.m$^{-2}$) has a noticeable influence on surface pressure patterns (Mean Sea Level Pressure – contours in hPa). Note how troughs develop during the austral summer months over areas of high HEAT radiation.

During summer months about 150 W.m$^{-2}$ of energy is emitted as sensible HEAT in south-western Africa. How does outgoing HEAT influence atmospheric circulation?

Outgoing long-wave radiation in the form of HEAT results in lower atmospheric pressures, convection and the rotation of air masses.

SEASONAL ATMOSPHERIC CIRCULATION AND MOISTURE TRANSPORT OVER NAMIBIA

General circulation patterns (Wind streamlines – m.s$^{-1}$) are linked to pressure disturbances as a result of surface HEAT. These atmospheric patterns are responsible for moisture flux towards the east of the Angola Low (north-east Namibia) and east of South Africa during austral summer months – as indicated by Specific Humidity – shaded in kg.kg$^{-1}$x 1000) variability.

ERA Interim Reanalyses data: monthly sensible heat flux (W.m$^{-2}$) and mean sea-level pressure (hPa) as calculated over the 20-year period 1986-2005.
Average (1980 – 2010) of seasonal rainfall totals (mm) as captured by Global Precipitation Climatology Centre (GPCC) data.

Rainfall total (mm)

Average (1980 – 2014) of seasonal near-surface temperature (°C) as captured by NCAR-NCEP reanalyses data.

Spatial averaged estimated rainfall time series (1980 - 2010) for the Northern part of Namibia.

Spatial averaged estimated rainfall time series (1980 - 2010) for the Central part of Namibia.

Source: Global Precipitation Climatology Centre (GPCC) http://gpcc.dwd.de
Modelling of the Atmosphere:
- Conservation of momentum;
- Conservation of mass;
- Conservation of energy.

Models are computer programmes developed to "solve" the atmospheric equations.

Experimental Design
Results from an ensemble of four European based ocean-atmosphere Coupled Global Circulation Models (CGCM), which were accommodated with the IPCC AR5, were considered for generating historical and future climate projections:

HadGEM2-ES ocean-atmosphere CGCM
United Kingdom (UK) Hadley Centre (Caesar et al., 2013);

EC-EARTH ocean-atmosphere CGCM
EC-Earth consortium, coordinated by the Royal Netherlands Meteorological Institute (KNMI) (Hazeleger et al., 2012);

Coordinated Downscaling Experiment (CORDEX)
Grid resolution of 449 x 0.64° (=50km x 50km).

CNRM-CM5 ocean-atmosphere CGCM
National Centre for Meteorological Research (CNRM), Climate Modelling and Global Change team, France - Météo France (Voituret et al., 2011);

MPI-ESM-LR ocean-atmosphere CGCM
Max-Planck-Institut für Meteorologie (Egorgeta et al., 2013).

It is all about \text{\textbf{HEAT}} (W.m^{-2}) = \text{Energy}

Solar energy entering Earth system = 341 W.m^{-2}
minus about 30% (= 102 W.m^{-2}) reflected = 239 W.m^{-2}

Greenhouse gases:
- Water vapor (H\text{2}O)
- Carbon dioxide (CO\text{2})
- Methane (CH\text{4})

Without greenhouse
\hspace{100pt} 239 W.m^{-2} \rightarrow \hspace{100pt} \text{18}^\circ \text{C}

Greenhouse
\hspace{100pt} 239 W.m^{-2} \rightarrow \hspace{100pt} \text{+15}^\circ \text{C}
It is all about \textit{HEAT} (W.m$^{-2}$) = Energy

Global Anthropogenic Radiative Forcing (W.m$^{-2}$) for the high RCP8.5, the medium-high RCP6.0, the medium-low RCP4.5 and the low RCP3-PD CO$_2$ concentration pathways.

In addition, two supplementary extensions are shown, connecting RCP6.0 levels to RCP4.5 levels by 2250 (SCP6to45) or RCP45 levels to RCP3-PD concentrations and forcing (SCP45to3PD).

Projected change from the MEAN

\textit{RCP8.5}: Annual temperature change (ºC) relative to 1985-2005

\textit{RCP4.5}: Annual rainfall change (mm/year) relative to 1985-2005

Projected change from the MEAN - RCP4.5

Seasonal temperature change (ºC) for 2046–2065 (+50 years) - relative to 1985-2005

Reference:

http://www.pik-potsdam.de/~mmalte/rcps/
**SUMMARY**

Future projections of near-surface temperature and rainfall in Namibia could be summarised as:

**Near-surface temperatures:**
- **Medium-to-low concentration pathway:**
  - 1.5°C to 2.5°C (+50 years)
  - 2.0°C to 3.0°C (+80 years)
- **High concentration pathway:**
  - 2.0°C to 3.0°C (+50 years)
  - 3.0°C to >5.5°C (+80 years)

**Rainfall:**
- **Medium-to-low concentration pathway:**
  - **Annual:** Wetter along the coast (up to +30%) Drier in the interior (up to -20%)
  - **Seasonal:** Variable (wetter along coast DJF, MAM and north JJA; rest drier)
- **High concentration pathway:**
  - **Annual:** Wetter along the central coast (+10%) Drier in the interior (up to -30%)
  - **Seasonal:** Drier DJF and SON, Wetter MAM and JJA in north (up to +100%)

**South African Weather Service**

**Multi-Model Seasonal Forecasting System – Sep 2014**

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**Thank you**

Dankie

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