CCDA-V

Africa, sustainable development and climate change

Prospects of Paris and beyond

ClimDev-Africa

A local diagnosis of the Hadley circulation over South Africa

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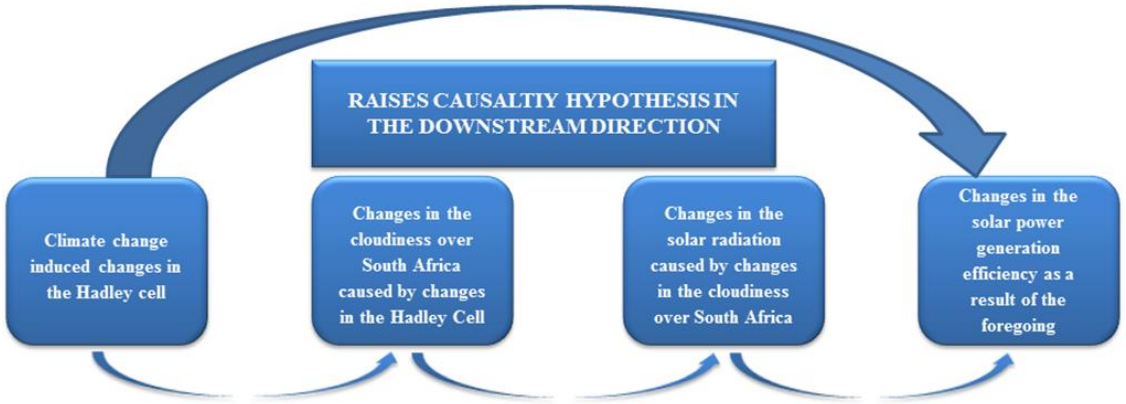
Problem statement 1/2

- In its Integrated Resource Plan (IRP) 2010, the South African government has identified a number of renewable energy options to inform the country's energy mix on the 2030 horizon and beyond.
- Solar energy is one of them.
- Solar power generation is mainly influenced by large scale cloud formation.
- Cloud formation might be impacted by climate change, increasing greenhouse gasses
- Opportunities or threats to South Africa's renewable energy industry and hence the generation of electricity from the solar energy resource.

Problem statement 2/2

- Links between the descending branch of the Hadley cell, cloudiness, solar radiation (as a renewable energy resource) over South Africa.
- The unavailability of local Hadley cell diagnostics have prevented a detailed dynamical analysis of increasing greenhouse gas (GHG) concentrations on changes in the subtropical branch of this cell over South Africa, and its subsequent impacts on large scale cloud formation and solar generation
- Can a causal knock on effect of climate change induced changes in the subtropical branch of the Hadley cell on cloud formation and solar power generation be established over South Africa?



Methods

- **Data**
- The National Centre for Environmental Prediction reanalysis (NCEPII, Kinamitsu et al., 2002) for the period 1979-2013.
- **Methods**
- The zonally-averaged mass stream function.
- The Ψ stream function method is used to partition the irrotational part of the three dimensional flow into a pair of orthogonal two-dimensional circulations.

$$\Psi = \frac{2\pi a \cos\varphi}{g} \int_0^p \bar{v}\, dp$$

$$m_\lambda = -\frac{\omega_\lambda}{g}\cos\phi \qquad m_\phi = -\frac{\omega_\phi}{g}\cos\phi$$

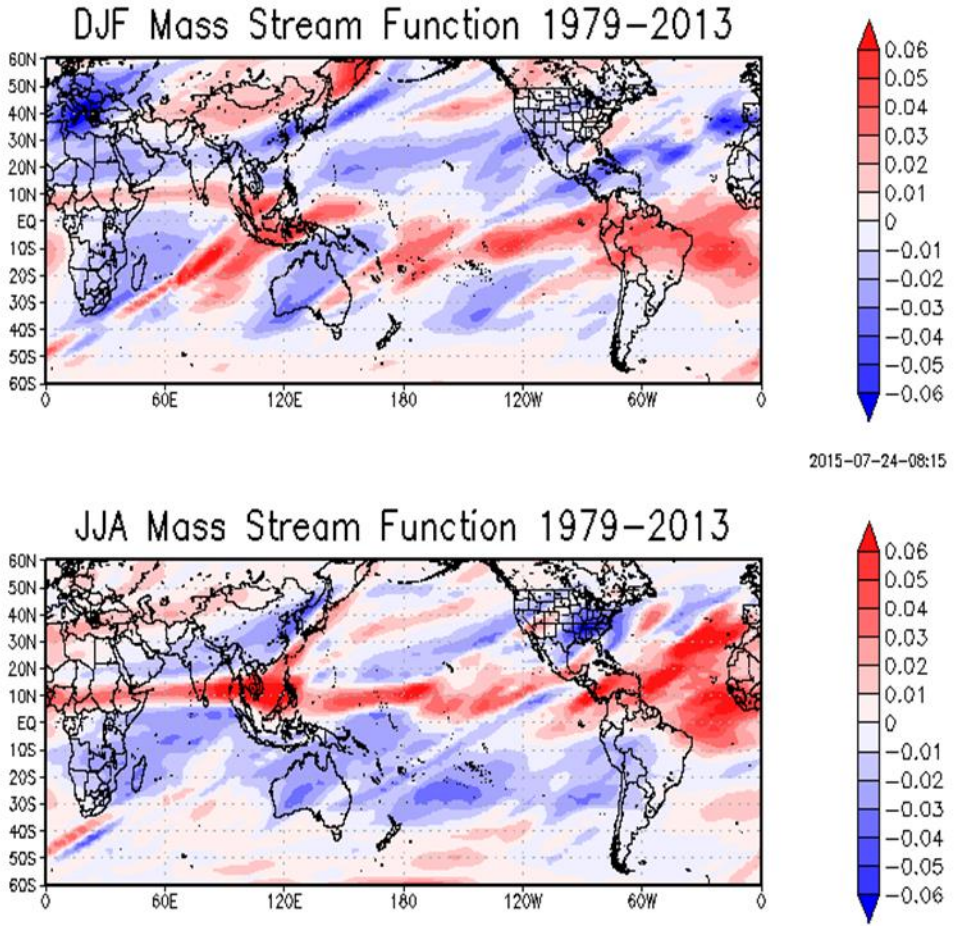
Key Findings

Mass stream function subsidence is more pronounced during December to February (DJF) than in June to August (JJA).

During DJF (JJA) the ascent (subsidence) is more prominent in the SH

while subsidence is more significant in the NH.

South Africa‘s experiences downward mass stream function for both DJF and JJA.



Key Findings

Zonally-averaged MMS

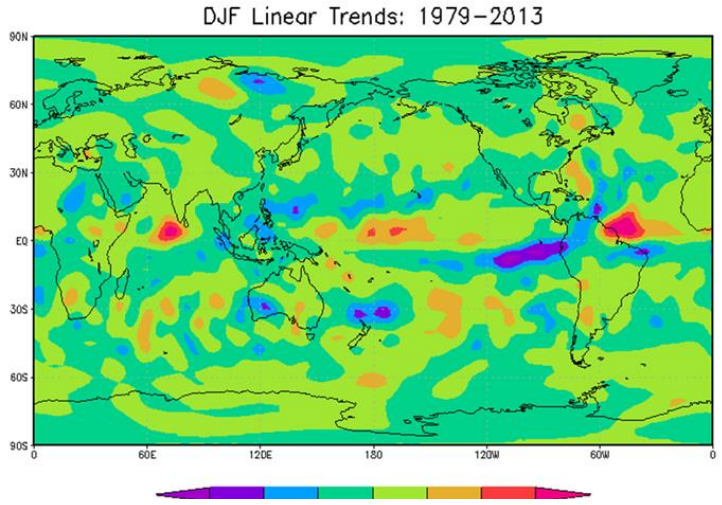
Generally positive trends for both DJF & JJA for both hemisphere

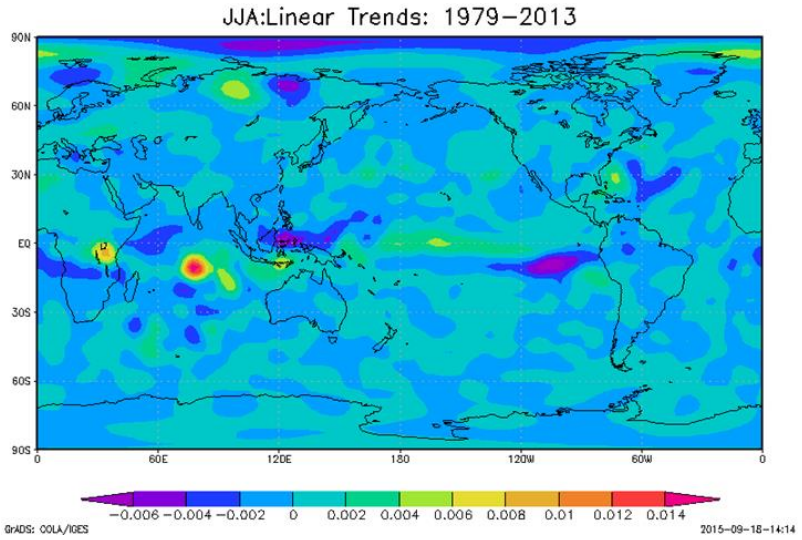
Ψ stream function method

Regional differences are notable.

Strong increase south of Asia and west of western Africa.

Southern parts of Africa indicate a strong increase during DJF and slight decrease during JJA.





Conclusions/Recommendations

- The Ψ stream function method Keyser et al (1989) provides useful way for diagnosing the changes in Hadley cell locally.
- Regional changes were noted.
- In general positive trends of the Hadley cell were noted
- Advocates that the Hadley cell is strengthening and it is zonally asymmetric.
- Way-Forward –
- Use more than one reanalysis data
- A combined climatology, trends of the local Hadley circulation, cloud cover and sunshine will be attempted.