INFLUENCE OF SPACE WEATHER ON ATMOSPHERIC ELECTRICITY AND WATER CYCLE

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Motivation

Many studies demonstrate the influence of space weather on atmospheric processes but there are no available physical theory of the phenomena which describes all features of the interaction.

Subject

The influence of solar activity on the global water cycle is the subject of our investigation.
Outline

- Space Weather
- Atmospheric Electricity
- Water Cycle
- Conclusions
Space weather

Solar activity influences on planetary magnetic field and cosmic ray flux intensity

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Modulation potential has positive correlation with sun spot number: \( \Phi = 373 + 3.535 \times W \)
Cosmic ray induced ionization

In our simulations we used the model of Cosmic Ray Induced Ionization (Usoskin and Kovaltsov, 2006; Usoskin et al., 2010)
Atmospheric electricity

Wilson’s theory:
- The Earth has negative electrical charge
- Negative lightnings are the main source of the Earth’s charge
- Thunderclouds generate electricity

Frenkel’s theory:
- The Earth has zero electrical charge
- Lightnings are a part of electrical currents
- All clouds generate electricity
Global atmospheric circuit

- Tropospheric clouds are the main source of electric energy in the atmosphere
- The Earth electric charge equals zero
- Direction of conductivity electric current is downward in fair weather regions and upward in cloudy regions
- Solar activity influences on electric current strength
Cloud electrical generator

(Imyanitov and Chubarina, 1965)
Influence of space weather on atmospheric electricity

- Solar modulation potential changes from 400 to 1200 MV during solar cycle
- Cosmic ray induced ionization decrease air electric resistance and increase electric current density
- Solar modulation of electric current density is about 10%
What is the way of atmospheric electricity influence on water cycle?
Experimental measuring system

Diagram showing the connections between an Air Ionizer, Digital Scales, and an Ion Counter.
### Methodology of laboratory experiments

#### Evaporation rate ($W/m^2$)

$$LE = -\frac{L}{S} \frac{\Delta M}{\Delta t}$$

#### Electrical conductivity current density ($A/m^2$)

$$j = \sigma E_z$$

*here*

$$\sigma = q_+ b_+ N_+ - q_- b_- N_-$$

$$E_z = \frac{U}{h}$$
Results of experiments

<table>
<thead>
<tr>
<th>Charnock constant</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.011</td>
<td>(Smith, 1988)</td>
</tr>
<tr>
<td>0.012</td>
<td>(Charnock, 1955)</td>
</tr>
<tr>
<td>0.019</td>
<td>(Wu, 1980)</td>
</tr>
<tr>
<td>0.037</td>
<td>(Kitaygorodsky and Volkov, 1965)</td>
</tr>
<tr>
<td>0.050</td>
<td>(Deacon et al., 1956)</td>
</tr>
<tr>
<td>0.077</td>
<td>(Hay, 1955)</td>
</tr>
<tr>
<td>0.079</td>
<td>(Laykhtman and Snopkov, 1970)</td>
</tr>
</tbody>
</table>

Evaporation rate:
\[ LE = \frac{L\alpha_s \kappa^2 U_{10}^2}{ln^2 \left( \frac{z_{10}}{z_0} \right) R_d T_{10}} \left( e_0 - e_{10} \right) \]

Roughness of water surface:
\[ z_0 = \frac{\alpha_z U_\ast^2}{g} \]

Conclusion
Solar activity influences on evaporation rate by atmospheric electricity
## Water cycle simulations

### Table: Simulated water cycle parameters

<table>
<thead>
<tr>
<th>Charnock constant</th>
<th>Evaporation (mm/month)</th>
<th>Precipitation (mm/month)</th>
<th>Precipitable water vapour (mm)</th>
<th>Water exchange (%/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>84.57</td>
<td>84.56</td>
<td>24.18</td>
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<td>0.02</td>
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<td>86.13</td>
<td>24.34</td>
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<td>0.03</td>
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<td>86.31</td>
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<td>11.67</td>
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<td>0.04</td>
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<td>87.28</td>
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<td>11.59</td>
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<tr>
<td>0.05</td>
<td>87.99</td>
<td>87.99</td>
<td>25.62</td>
<td>11.45</td>
</tr>
</tbody>
</table>

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Conclusions

So, we can assume that solar activity influences on atmospheric processes by changing the parameters of the global atmospheric electrical circuit and the water cycle. Indeed, the analysis of satellite data showed the dependence of precipitable water vapour on the galactic cosmic rays flux.
Thank you for your attention!