# Cometary Activity

# Rosetta activity – variation and evolution

**Understanding activity → understanding ice inside the nucleus**

**Understanding ice → understanding early solar system history/conditions**

**Understand link between gas and dust → mostly observe dust from Earth**

## Before Rosetta

- 7 Comets visited by spacecraft
  Only flybys taking snapshots
- More observations with remote sensing instruments
  Only a limited number of molecules and dust observble
- Observations when comets were close to the Sun / active

## With Rosetta

- > 2 years of measurements
  Does activity change over time?
- Rosetta is mobile
  Look at activity from different angles and positions around 67P
- Rosetta is sensitive
  Many species can be observed

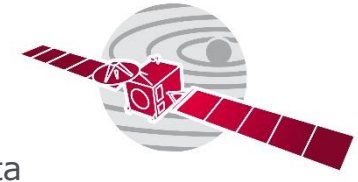
# Activity far away from the Sun


At distances typical for Rosetta there is about **one millionth of a millionth** as much gas as on Earth

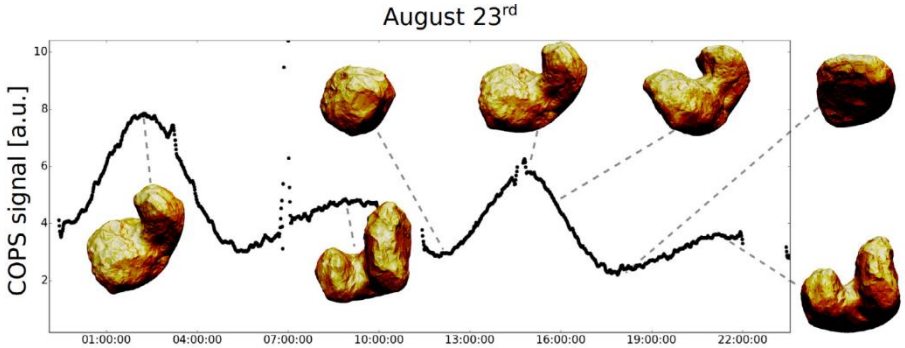
Rosetta is sensitive indeed!

- 67P was already active when Rosetta arrived at the Comet. No “turn on” was detected
  (1st $H_2O$ detection 06-06-2014 MIRO)
- Not only the super-volatiles produced at these distance
  Expected CO, $CO_2$ and $H_2O$ but found many more molecules with higher sublimation temperature
- Most $H_2O$ from sunlit part of 67P
  **$H_2O$ cannot come from deep inside nucleus. It would not follow the sub solar point so far away from the Sun**

# Activity is illumination driven …mostly …for most species

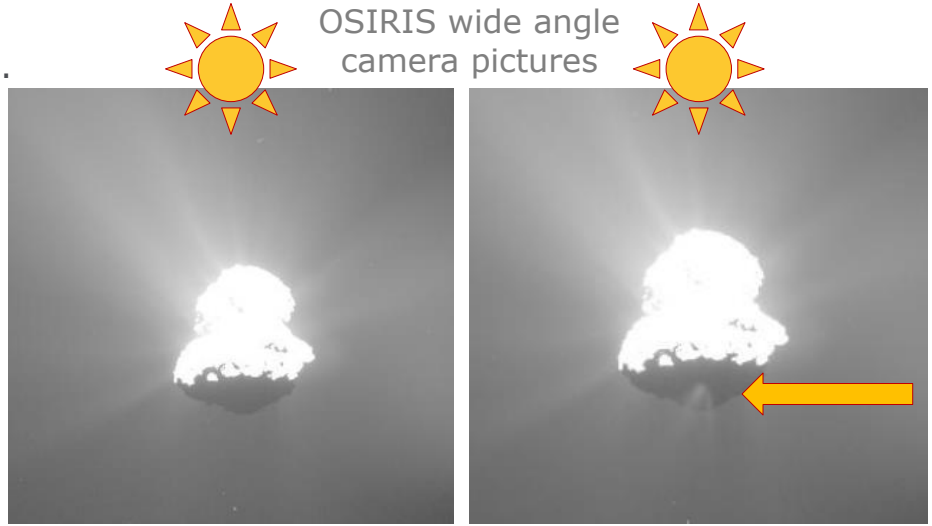


- Over one orbital path: Comet gets more active the closer to the Sun → known before
- Observation of diurnal changes in activity → needs long term experiment such as Rosetta
  Different behaviour of different species hold information on ice conditions on the nucleus.
- Activity is modified by cometary seasons over multiple orbits → see next slide
- There is activity on the night side
  Dust jets remaining active on the night side
  Dust jets even start becoming active on the night side.




24 hours of pressure measurements by Rosina COPS starting 23-08-2014

OSIRIS wide angle camera pictures



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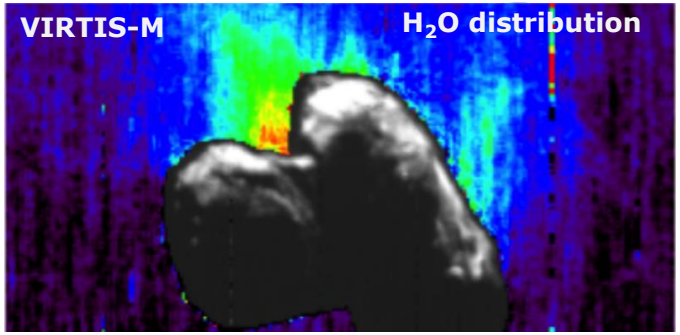
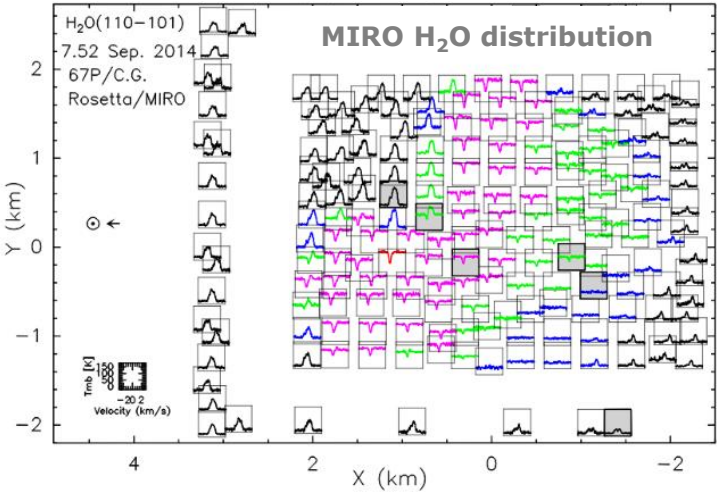
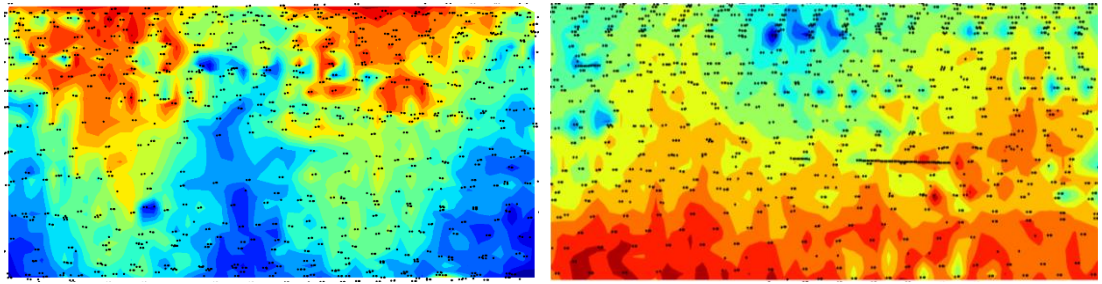
# Activity is heterogeneous

- Northern hemisphere has 6.4 years of summer and southern hemisphere only 10 months!
- Southern summer is much warmer because it happens close to the Sun.
- **Comets don't care for taxonomy/classification, what you find depends where you look and when you look at them.**
- **Snapshots are not representative measurements!**



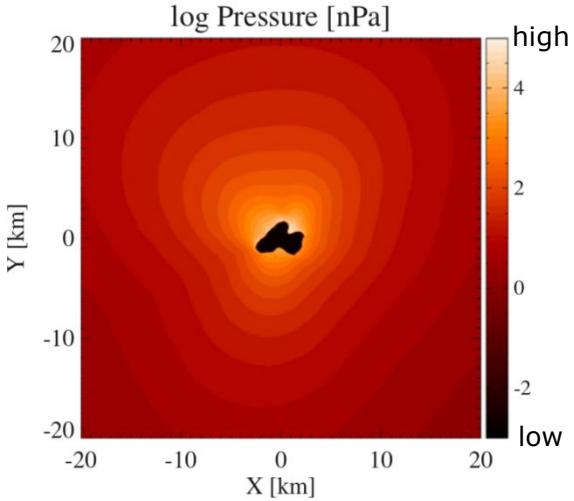

ROSINA $H_2O$ distribution

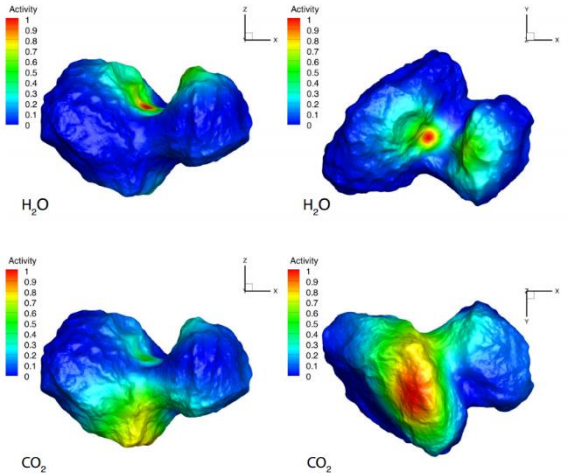


December 2014 September 2015

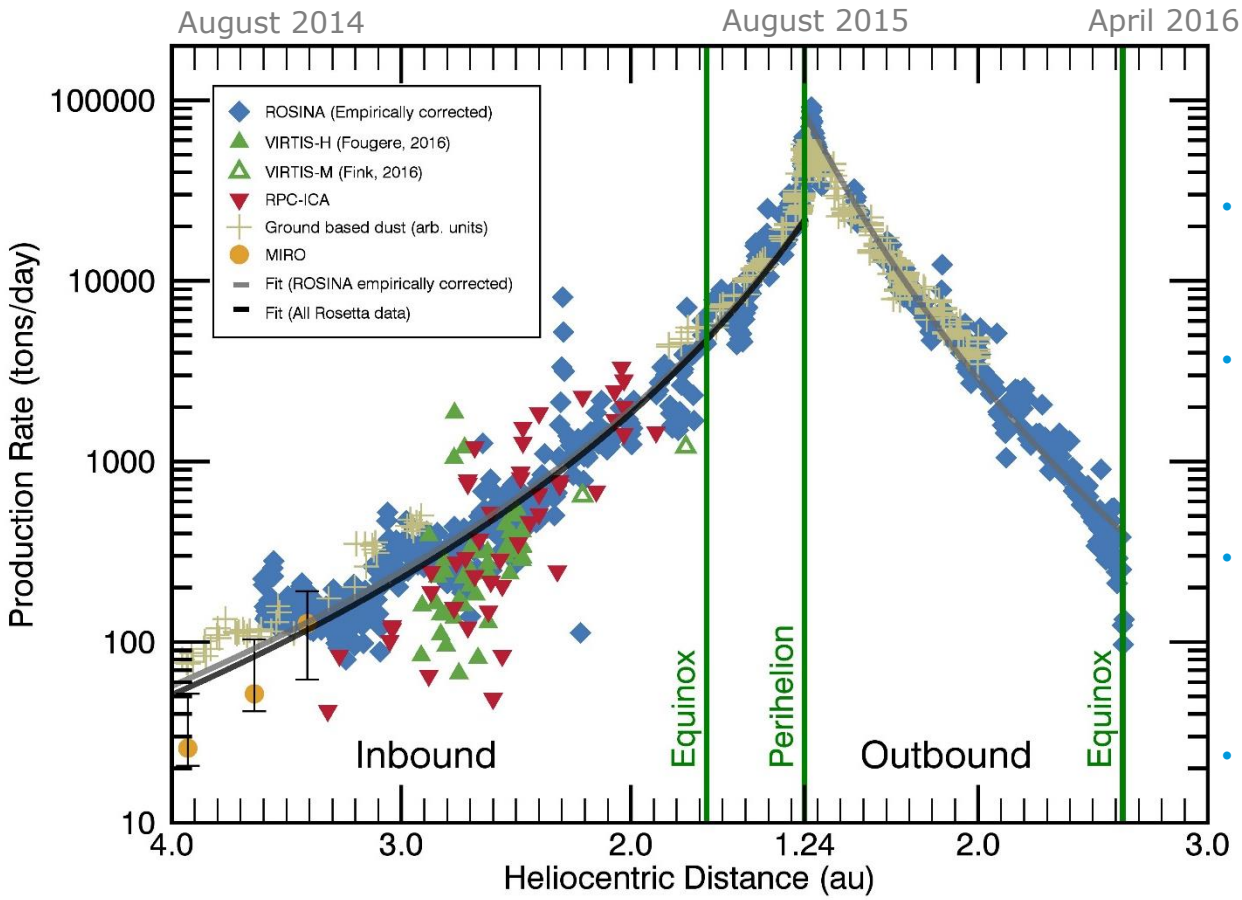
# Computer Simulations as Link between Instruments

- Every instrument is highly specialized towards a specific set of measurements, none of them will get the whole picture on its own.
- Computer simulations are necessary to enable a comparison
  Compare Temperature measurement to a squiggly line to a photographic picture
- ~1 Million CPU hours used to understand outgassing of 67P (more than 114 years!)



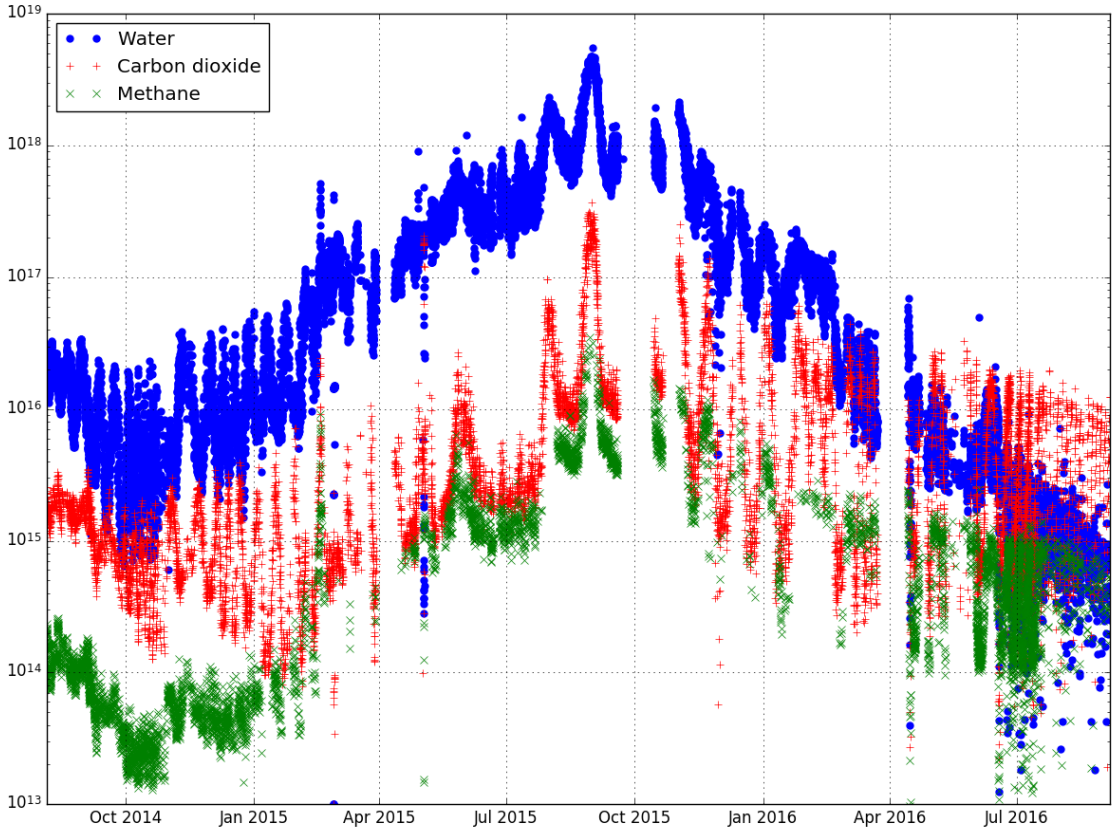



# Production Rate Profiles I




- Multi-Instrument agreement on activity evolution
- Compute total mass loss from profile 2-4 meters of comet surface lost per orbit around the Sun
- Gas and dust production follow similar patterns. Link between dust and gas is crucial for understanding comets.
- Gas/Dust ratio remains ~constant over one orbit

# Production Rate Profiles II




- Different types of ice trap and release gas in specific ways.
- Production rate profiles are a proxy for trapping and release mechanism.
  How much of what species was trapped
  When does the comet release what species
- **The type of ice on the nucleus is important to understand what happened (or what not happened!) during the formation of our solar system**
- **The jury is still out! More laboratory and modelling work necessary**

# Summary and Outlook

- Many new discoveries; heterogeneity on different scales, different outbursts, seasonal effects, diurnal effects, dust to gas ratio. And most of it changes over time…

- Do we really understand how comet activity works now? → certainly better than before, and…
  - Only small fraction of data has really been analyzed so far (~5% ?)
  - Rosetta mission might end now, but there is
    **enough data for decades of high quality science**
    We have (all?) the pieces…