Potential science with ALMA
as predicted by numerical simulations

SOLAR SIMULATIONS FOR THE ATACAMA LARGE MILLIMETER OBSERVATORY NETWORK

SSALMON

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The Atacama Large Millimeter/submillimeter Array (ALMA)

ALMA is a valuable tool for observing the chromosphere of our Sun at (sub-)millimeter wavelengths at high spatial, temporal and spectral resolution with large potential to address long-standing scientific questions in solar physics. ALMA is an international co-operation between Europe, North America, East Asia and Chile. The interferometric array is located on the Chajnantor plateau in the Chilean Andes at an altitude of 5000 m and consists of 66 antennas (54 of them with a diameter of 12 m and 12 with 7 m diameter, see Figs. 1-2). By combining the antennas, they act like a giant telescope with baselines of up to 16 km. Once completed, every antenna will be equipped with receivers covering 10 frequency bands in the range from 31 GHz to 950 GHz (9.6 mm to 0.3 mm). The specially designed antenna surfaces and further technical adjustments (incl. solar filters) allow for observing the Sun. First test observations of the Sun have already been carried out.

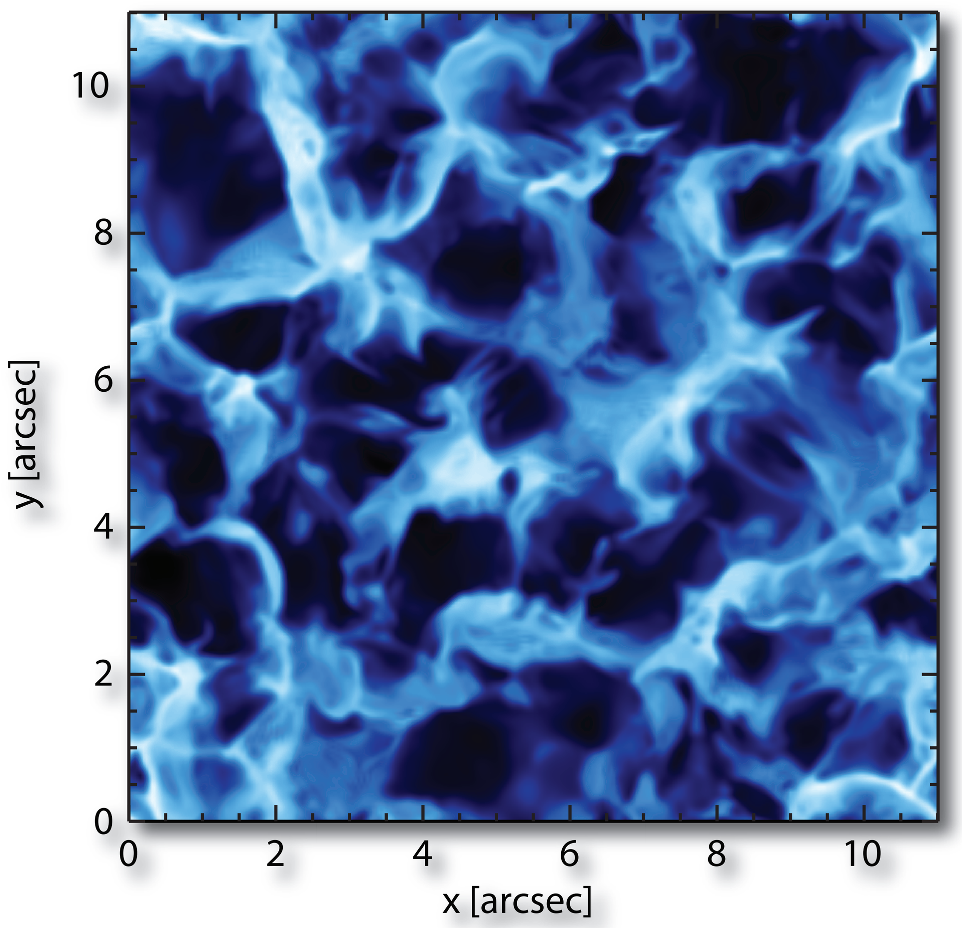

Fig. 3: *Synthetic brightness temperature map at λ = 1 mm.*
Credit: Wedemeyer–Bohm, University of Oslo (2011)

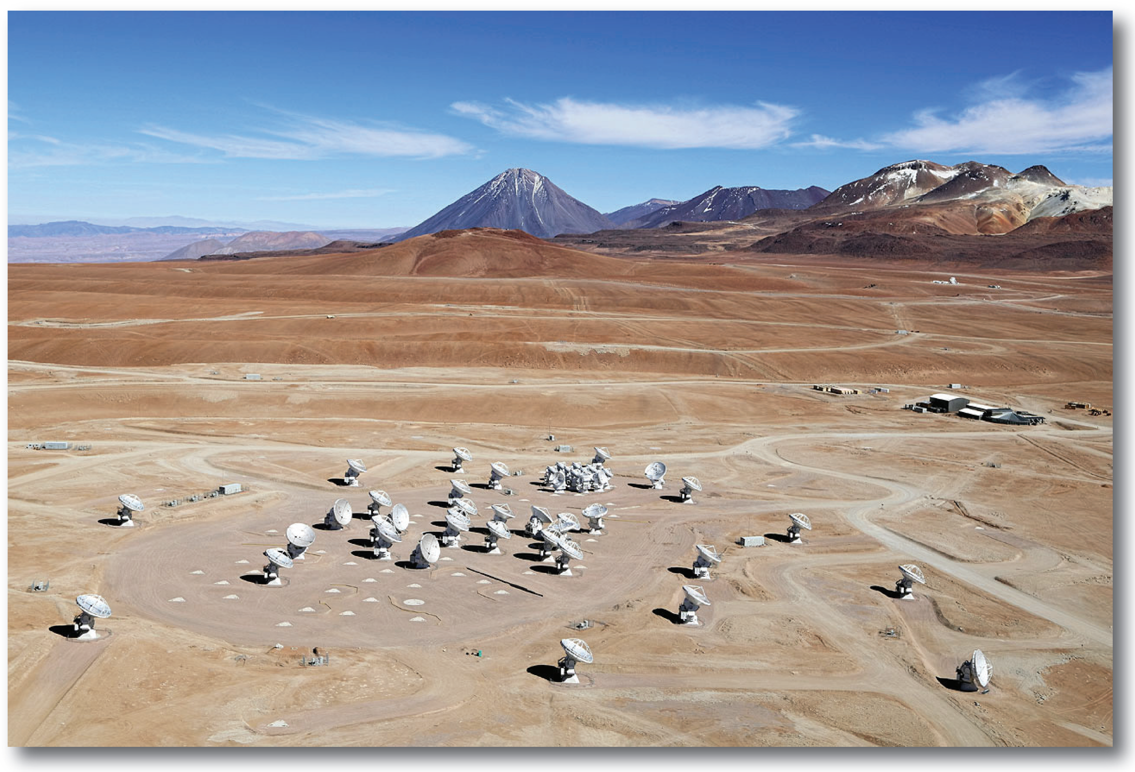

Fig. 1: *Aerial view of the antenna array on the Chajnantor Plateau in the Chilean Andes.*
Credit: Clem & Adri Bacri-Normier (wingsforscience.com)/ESO

Fig. 2: *ALMA antennas with diameters of 12m. The last anntenna just arrived in June 2014 on the plateau.*
Credit: ALMA (ESO/NAOJ/NRAO)/L. Calçada (ESO)/H. Heyer (ESO)/H. Zodet (ESO)

ALMA observations of the solar chromosphere

The radiation at ALMA wavelengths orginates from the low to high chromosphere (and the transition region), where the formation height generally increases with wavelength. The continuum radiation is mainly due to thermal free-free emission, which occurs essentially under LTE conditions with a Planckian source function. Consequently, ALMA effectively acts as a **linear thermometer** of the solar chromosphere and provides measurements of plasma conditions, which are in principle much easier to interpret than other diagnostics in the UV and visible range. In addition, synchrotron radiation due to high-energy electrons will be observable with ALMA (especially during flares). Spectral lines in the ALMA range provide yet to be developed diagnostic tools (recombination lines, Zeeman effect, molecules).
Potential scientific applications include the dynamics, thermal structure and energy transport in the **"quiet" solar chromosphere, active regions and sunspots, spicules, prominences and filaments, and flares.**

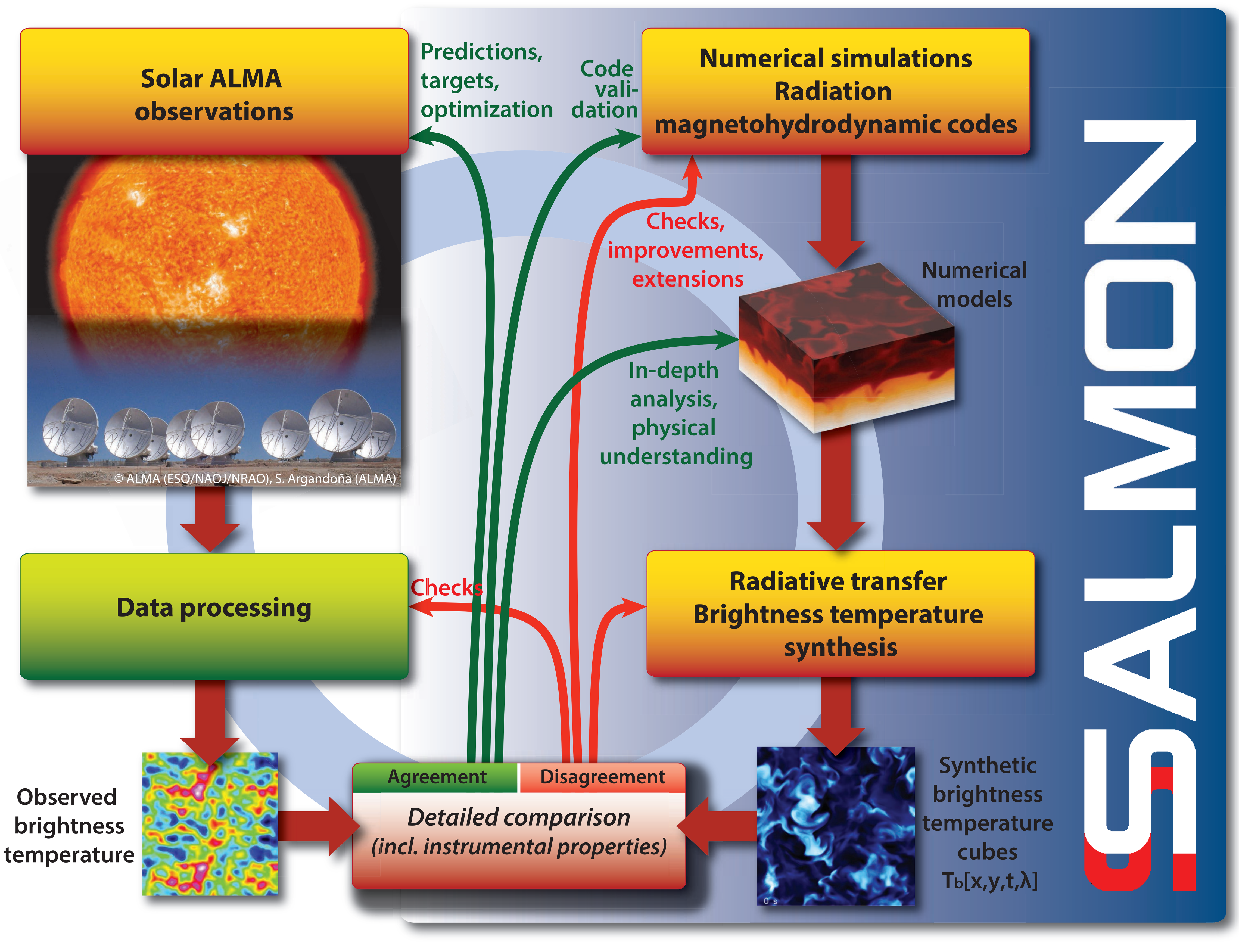

Fig. 4: Detailed comparisons with ALMA observations (left) with numerical models (right) enable us to develop observing strategies for ALMA, to plan, optimize, and interpret observations, and to demonstrate that potentially important scientific results can be expected from solar ALMA observations.

The role of numerical simulations

Numerical simulations of the solar chromosphere can play an important role for the planning, optimizing and interpretation of observations with ALMA. Synthetic brightness temperature maps, which are calculated from numerical models (see Fig. 3), can be used to simulate what ALMA would observe. Different instrumental set-ups can be tested and adjusted to the scientific requirements, finding the optimal set-up for different scientific applications. The general procedure is outlined in Fig. 4.

SSALMON - An international network

The network was initiated in connection with two currently ongoing international development studies:

"Advanced Solar Observing Techniques" - A project within the **North American Study Plan** for Development Upgrades of the ALMA (PI: T. Bastian, NRAO, USA).

"Solar Research with ALMA" - A project carried out at the **Czech node of European ALMA Regional Center** (EU ARC at Ondrejov, Czech Republic) in the frame of the ESO program "Enhancement of ALMA Capabilities/EoC", (PI: Roman Brajsa, Hvar Observatory, Croatia).

The activities of the network will focus on all related simulation and modelling aspects ranging from calculating models of the solar atmosphere, producing synthetic brightness temperature maps, applying instrumental effects, comparisons with real ALMA observations of the Sun to developing optimized observation strategies.

The aims of the SSALMONetwork

Key goal 1: Raising awareness of science opportunities with ALMA. Simulations can demonstrate what could be possibly observed with ALMA and which scientific problems could therefore be addressed in the future, also in combination with other ground-based and space-borne instruments.

Key goal 2: Clear visibility of solar science within the ALMA community. A demonstration of potentially important scientific results will help to allocate a fair share of the observing time for solar campaigns.

Key goal 3: Constraining ALMA observing modes through modeling efforts. Simulations in comparison with ALMA observations will help to develop optimal observation strategies and to plan and analyze solar observations.

The network is open to everybody who has a professional interest in contributing to potential ALMA solar science, which include or require simulations.

More information and registration at
http://ssalmon.uio.no