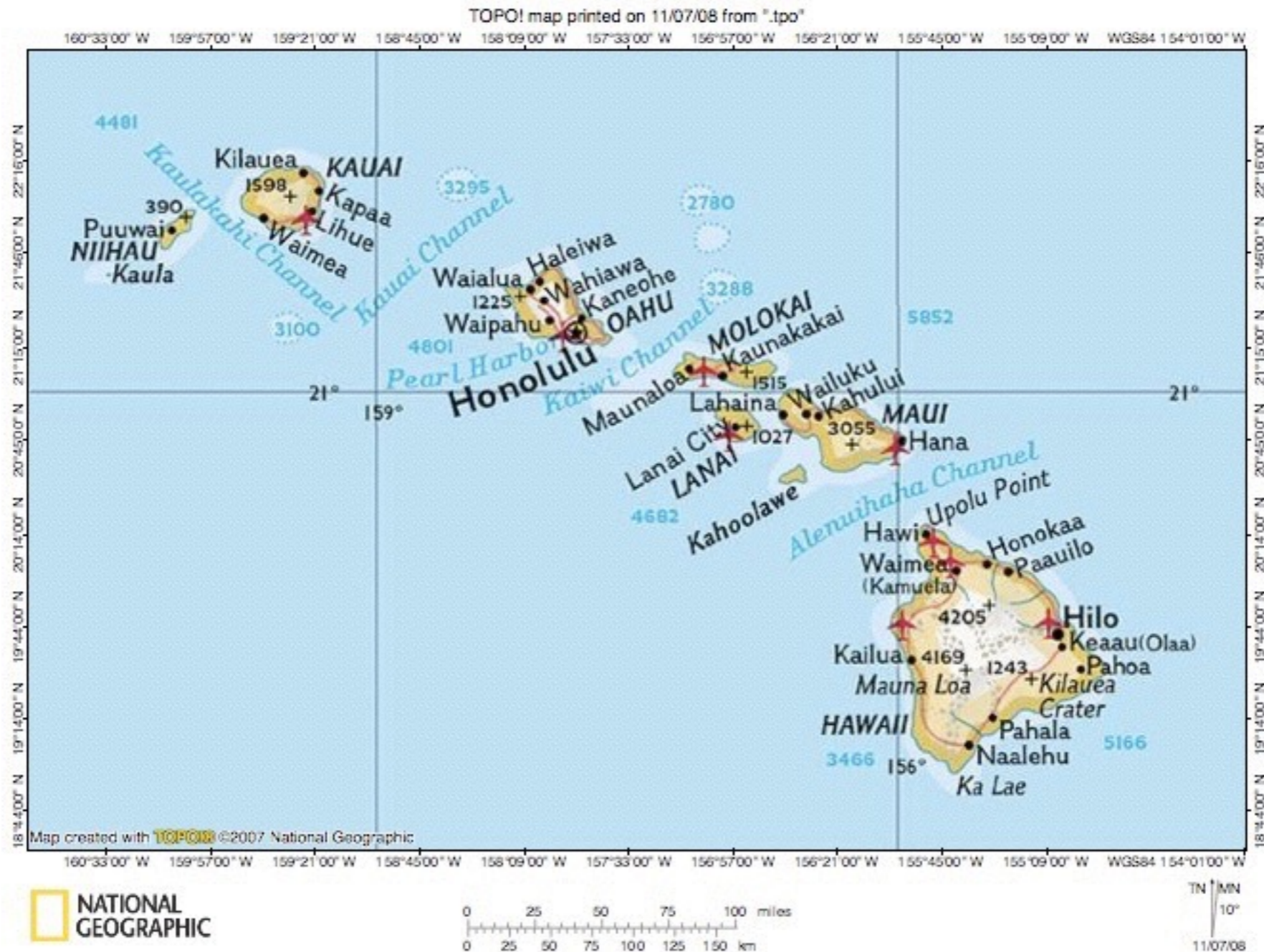
A night sky photograph showing the Milky Way galaxy. The galaxy's core is visible as a bright, yellowish-white band of stars and dust, stretching across the middle of the frame. The surrounding sky is filled with numerous individual stars of various colors, including blue, white, and red. In the lower-left foreground, there is a dark silhouette of a person's head and shoulders, looking towards the sky. The overall scene is a clear view of the night sky from a dark location.

Protection of Hawaii's observatories from light pollution and radio interference

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Mauna Kea is on the island of Hawaii
 Haleakala is on the island of Maui

Kauai has some of the best lighting in Hawaii because of its bird population

Population growth

- ✦ Many of the world's major observatories are located in areas of rapid population growth
 - ✦ Arizona
 - ✦ Canary Islands
 - ✦ La Serena - Coquimbo area of Chile
 - ✦ Kona coast of island of Hawaii

Hawaii:

1992/1998/2003



Island of Hawaii	30–60 km	185,000
Maui	150 km	155,000
Oahu (Honolulu)	300 km	980,000
Kauai	480 km	70,000

Hawaii: 1992/1998/2003

● Mauna Kea

Sports field and Golf facility





Local light sources dominate over distant sources

Honolulu is 300 km away

Lighting laws in the US

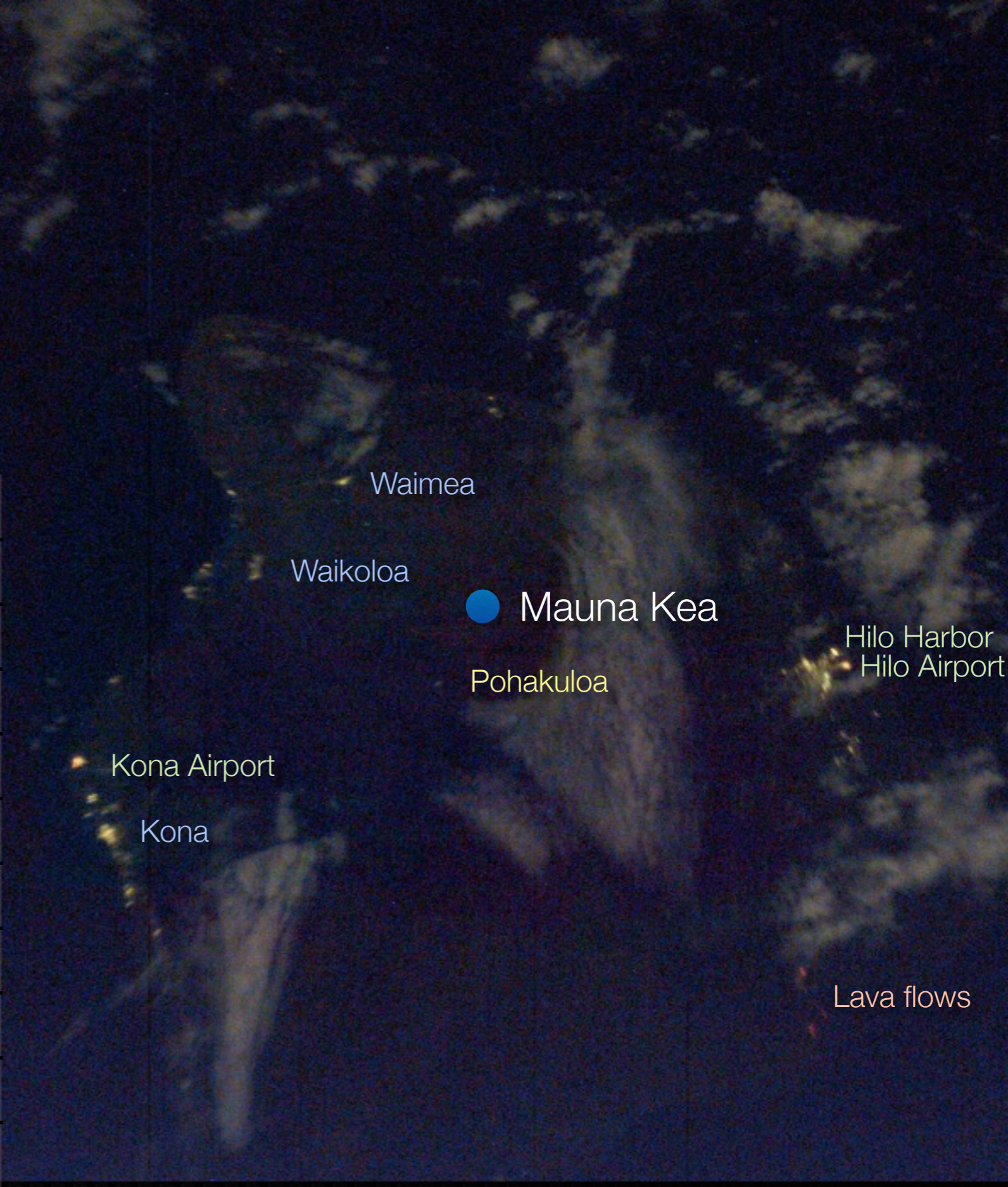
- ✦ Unlike the Canary Islands and Chile, in the United States, lighting ordinances are typically at the county or occasionally state level
- ✦ This derives from the US Constitution, which defines the role of the federal and state governments, the supremacy clause in the constitution, and amendments 10 and 14 to the constitution

Lighting laws in the US

- ✦ In essence, there is a precedence of county < state < federal
 - ✦ This means that we need to deal with all levels of government
 - ✦ For example, military installations do not have to follow county lighting ordinances

ISS image of island of Hawaii: October 2003

Location	Brightness	Impact
Hilo Town Center	34,000	3
Hilo Mall Area	27,000	2.2
Kona Town	59,000	2.7
Waikoloa	22,000	3
Waimea	17,000	3.2
Hilo Airport	19,000	1.5
Hilo Harbor	19,000	1.5
Kona Airport	30,000	1.6
Pohakuloa	2,300	7.2
Lava flows	5,000	0.2



Pohakuloa Training Area

- ✦ Mauna Kea is very sensitive to lights at this army training area because it is close
- ✦ Retrofitting of some bad lights has occurred
- ✦ Unified Facilities Criteria for external lighting now adopted by all branches of military
 - ✦ Requires full shielding of all exterior lights
- ✦ Their own lights are affecting training with night vision equipment

Airports and Harbors

- ✦ The airports are the major source of broad spectrum light pollution seen in the ISS image
- ✦ New state law in 2007 requires airports and harbors to conform to county lighting ordinances
- ✦ Retrofitting of ramp lighting with fully shielded fixtures at Hilo and Kona airports would significantly reduce light pollution
- ✦ Reducing airport lighting when it is not needed can dramatically reduce light pollution (and save energy)



Hawaii county lighting ordinance

- ✦ Full shielding is now required for all new lights
- ✦ There are now strict limits on blue light
- ✦ Filtered LEDs are typically required for applications where white light is not required

Mauna Kea's dark sky

- ✦ The night sky over Mauna Kea is still extremely dark
- ✦ Clouds covering the lights on the Hilo side help
- ✦ Mauna Kea is the darkest site ever seen by the National Park Service night sky team, who measured the brightness of the night sky from Mauna Kea in July 2011

Revision of the Lighting Ordinance

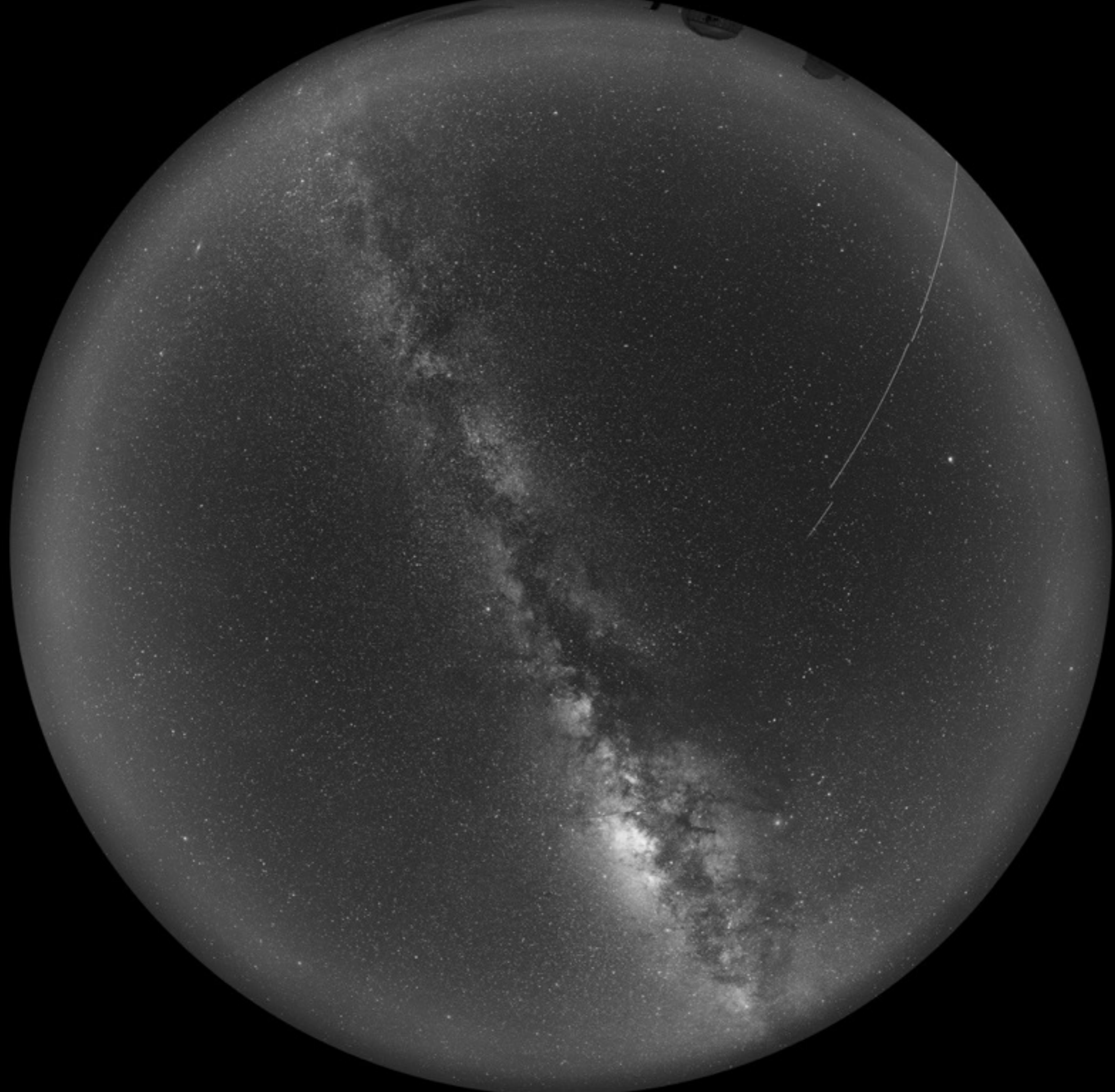
- Hawaii County has hired a consultant, Robert Billingsley, to advise on a complete revision of the lighting ordinance
- We have been working closely with the consultant for over a year
 - Draft 13 will be available shortly
 - Input into the ordinance has been widely sought
 - It has required compromise by all parties

Revision of the Lighting Ordinance

- ✦ New proposed features include
 - ✦ No induction lamps, restrictions on fluorescent lamps, and metal halide limited to recreational facilities
 - ✦ Widespread limitations on blue light
 - ✦ White light needs to have low correlated color temperature
 - ✦ Restriction on light emissions from greenhouses

Enforcement of the Lighting Ordinance

- ✦ Proper enforcement of the lighting ordinance is essential
 - ✦ Present enforcement is very lax
 - ✦ The new draft includes new penalties for violations
- ✦ The new draft includes astronomy as well as county approval of new light sources
- ✦ Some of the proposed changes involve spectral power distributions, and are more technical — this also presents an enforcement challenge



State Laws

- ✦ Billboards are banned in Hawaii
 - ✦ LED billboards are therefore not allowed
 - ✦ But there are a few small ones on military bases!

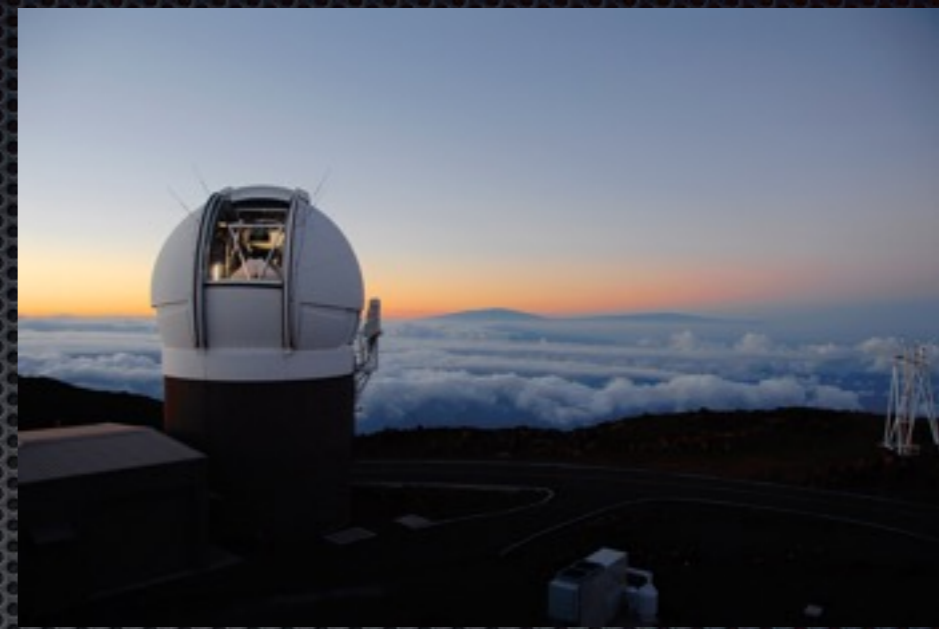
State Laws

- ✦ A state committee called the “Starlight Reserve Committee” met from 2009 to 2015 to discuss lighting in the State of Hawaii
 - ✦ A new law was passed in 2013 that required, for state government lighting:
 - ✦ Full shielding
 - ✦ Correlated color temperature of 4000K or below
 - ✦ Very good shielding for recreational lighting (e.g., school athletic fields)
 - ✦ Conformance to county ordinances

Starlight Reserves and Parks

- ✦ Preliminary steps have been made to start to establish possible starlight reserves or parks
 - ✦ The first problem we encountered was that most parks are closed at night
 - ✦ Looking at the sky at night from parks was a new concept
 - ✦ Present closures are based on discouraging homeless from sleeping in parks
 - ✦ Fisherman can access the shoreline at night

Maui



- ✦ The Pan-STARRS telescopes are located on Maui
- ✦ Maui has a lighting ordinance that requires all lighting be fully shielded, and includes a deadline requiring retrofit of all lights that aren't fully shielded
- ✦ It requires use of high pressure sodium
- ✦ The Maui county mayor would like to start using LEDs, but this has not yet been discussed by the council
 - ✦ The lighting ordinance on Maui is not well enforced

Maui

- ✦ Honolulu is approximately 160 km from Haleakala, and impacts the sky brightness on Haleakala
- ✦ It is difficult to separate Honolulu's contribution to the sky brightness from Maui's because the main population center on Maui is in the same direction as Honolulu seen from Haleakala



Oahu

- ✦ Oahu has no lighting ordinance
- ✦ Sky brightness are:
 - ✦ North shore – 2 x natural sky brightness level
 - ✦ Sandy Beach, Kailua – 6 x
 - ✦ Central Honolulu – 40 x

Oahu

- ✦ The county is planning to replace all streetlights with 4000K LEDs; most but not all will be fully shielded
 - ✦ Use of 4000K is very troubling — a warmer color should be used
 - ✦ Few people like the color of blue-rich LEDs
 - ✦ Just from the perspective of ambiance in Waikiki, a warmer color should be selected

Kauai

- ✦ Newell's shearwaters are endangered birds on Kauai that are attracted to unshielded lights
 - ✦ They circle the lights until they become exhausted, then die or are attacked by predators
- ✦ The Federal Endangered Species Act has required that all lights are properly shielded; Kauai now has state-of-the-art recreational lighting

Kauai

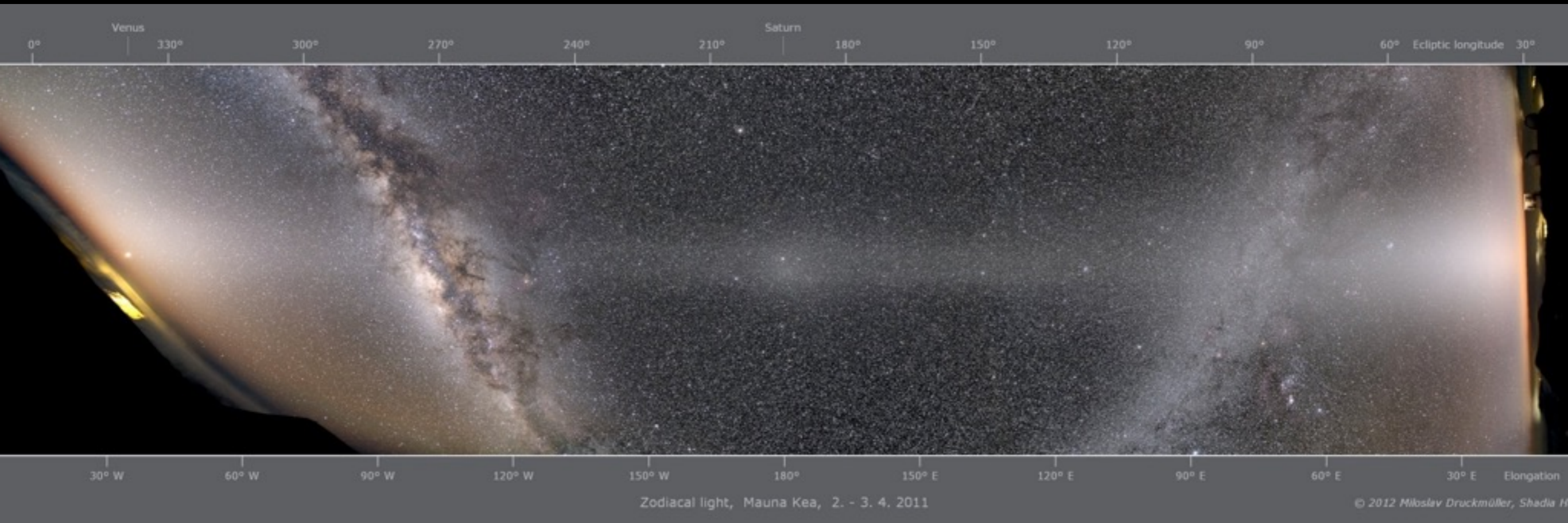
- ✦ As a result, Kauai has some of the best lighting in the world in terms of shielding
- ✦ Kauai would like to switch to LEDs, but this does not appear to have started
- ✦ Newell's shearwaters appear to be most affected by blue and green light — this means that warm colored or filtered LEDs are likely to have the least effect on the endangered birds

Radio frequency interference

- ✦ On Mauna Kea
 - ✦ Fixed radio transmitters are not allowed
 - ✦ Wi-fi is not allowed
 - ✦ Weather radar is sector blanked
 - ✦ Cellular phones should be turned off

Radio frequency interference

- ✦ On Haleakala
 - ✦ Powerful TV transmitters have been relocated from the summit area
 - ✦ Weather radar is sector blanked
 - ✦ There are still FAA radios and other government transmitters in the summit area, and there is little chance that these will be removed
 - ✦ We do not believe that these interfere with Pan-STARRS



Astronomy Picture of the day (April 5, 2012)
Miloslav Druckmüller and Shadia Habbal